

**Betsaida  
Alcantara/DC/USEPA/US**

01/12/2011 06:21 PM

To Gregory Peck, Stephanie Owens

cc

bcc

Subject NEED ANSWER: spruce

see below. do we?

----- Forwarded by Betsaida Alcantara/DC/USEPA/US on 01/12/2011 06:21 PM -----

From: "Tamarin, Nathanael P." (b) (5), (b) (6)  
To: Betsaida Alcantara/DC/USEPA/US@EPA  
Cc: "Carson, Jon" (b) (5), (b) (6)  
Date: 01/12/2011 06:17 PM  
Subject: FW: spruce

---

Betsaida- (b) (5)

Nate

Thanks,

-----Original Message-----

From: Carson, Jon  
Sent: Wednesday, January 12, 2011 6:01 PM  
To: Tamarin, Nathanael P.  
Cc: Wali, Sahar; Maher, Jessica A.  
Subject: FW: spruce

Hi Nate - ccing our Comms and Leg directors here. Attached and below are the embargoed press release, and internal talking points. below is their timeline.

(b) (5)

Sahar and Jess - Nate Tamarin is at Political Affairs, and does all work with organized labor. (b) (5)

Jon Carson  
Chief of Staff  
Council on Environmental Quality

(b) (6)

-----Original Message-----

From: Alcantara.Betsaida@epamail.epa.gov [mailto:Alcantara.Betsaida@epamail.epa.gov]  
Sent: Wednesday, January 12, 2011 5:22 PM  
To: Gavin, Tom  
Cc: Gilfillan.Brendan@epamail.epa.gov; Stevens, Clark; Wali, Sahar; Tuss, Taryn L.  
Subject: RE: spruce

(b) (5)

(b) (5) [REDACTED]

[REDACTED]

T [REDACTED]  
[REDACTED]

[REDACTED]  
T [REDACTED]

[REDACTED]

[REDACTED]  
[REDACTED]

[REDACTED]  
[REDACTED]

[REDACTED]  
T [REDACTED]

[REDACTED]

T [REDACTED]

[REDACTED]  
T [REDACTED]  
[REDACTED]

(See attached file: Spruce Press Release.docx)

From: "Gavin, Tom" (b) (6)

To: Betsaida Alcantara/DC/USEPA/US@EPA, "Wali, Sahar"  
(b) (6)

Cc: Brendan Gilfillan/DC/USEPA/US@EPA, "Stevens, Clark"  
(b) (6), "Tuss, Taryn L."  
(b) (6)

Date: 01/12/2011 05:16 PM

Subject: RE: spruce

(b) (5) [REDACTED]

[REDACTED]

-----Original Message-----

From: Alcantara.Betsaida@epamail.epa.gov [mailto:Alcantara.Betsaida@epamail.epa.gov]  
Sent: Wednesday, January 12, 2011 3:39 PM  
To: Wali, Sahar  
Cc: Gilfillan.Brendan@epamail.epa.gov; Stevens, Clark; Tuss, Taryn L.; Gavin, Tom  
Subject: RE: spruce

Here are the tps, we'll share press release shortly (See attached file: Spruce Talking Points.docx)

From: "Wali, Sahar" (b) (6)

To: Betsaida Alcantara/DC/USEPA/US@EPA, "Gavin, Tom" (b) (6), "Stevens, Clark" (b) (6), "Tuss, Taryn L." (b) (6)

Cc: Brendan Gilfillan/DC/USEPA/US@EPA

Date: 01/12/2011 01:49 PM

Subject: RE: spruce

Thanks, Betsaida. (b) (5)

Sahar Wali  
White House Council on Environmental Quality  
(b) (6)

-----Original Message-----

From: Alcantara.Betsaida@epamail.epa.gov [mailto:Alcantara.Betsaida@epamail.epa.gov]  
Sent: Wednesday, January 12, 2011 12:22 PM  
To: Gavin, Tom; Stevens, Clark; Wali, Sahar; Tuss, Taryn L.  
Cc: Gilfillan.Brendan@epamail.epa.gov  
Subject: spruce

(b) (5)

(b) (5) [Redacted]

[Redacted]

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Spruce Press Release.docx



Spruce Talking Points.docx











Matthew  
Klasen/DC/USEPA/US  
01/04/2011 01:07 PM

To "Shawley, Dianne M"  
cc  
bcc  
Subject Re: Contact Info.

Thanks Dianne, great to talk with you too. I'll send a note around to a group of folks here this afternoon.

Attached is the most recent draft of the RIA that we have. (b) (5) (This  
version was sent to us by John Craynon in October.)

(b) (5)

Thanks,  
Matt



ATTACHMENT REDACTED-DELIBERATIVE

OSM Regulatory Impact Analysis.101610.pdf

-----  
Matt Klasen  
U.S. Environmental Protection Agency  
Office of Water (IO)  
202-566-0780  
cell (202) 380-7229

"Shawley, Dianne M"	Matt - Great to talk with you and I appreciate...	01/04/2011 12:20:10 PM
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From: "Shawley, Dianne M" <dshawley@osmre.gov>  
To: Matthew Klasen/DC/USEPA/US@EPA  
Date: 01/04/2011 12:20 PM  
Subject: Contact Info.

Matt - Great to talk with you and I appreciate your assistance on the two issues we discussed. My contact info is below. I look forward to hearing from you later in the week.

Best,  
Dianne

Dianne M. Shawley  
Counsel to the Director  
U.S. Department of the Interior  
Office of Surface Mining

1951 Constitution Ave., N.W.

South Interior Building, Room 235  
Washington, D.C. 20240

Phone: (202) 208-4222

Fax: (202) 219-3106

[DShawley@osmre.gov](mailto:DShawley@osmre.gov)

**Bill Jenkins/R3/USEPA/US**  
01/04/2011 05:24 PM

To "Randy Pomponio", "Jeffrey Lapp", "John Forren", "John Krakowiak"  
cc  
bcc  
Subject Message from FWS about MIRA

Check this out. Christy sent this message today during the MIRA meeting. (b) (5)

Bill  
Sent by EPA Wireless E-Mail Services

---

**From:** Walt Galloway  
**Sent:** 01/04/2011 04:23 PM EST  
**To:** jenkins.bill@epa.gov  
**Subject:** Fw: Access to materials for the Surface mining analysis -- Federal Partners

---

**From:** Christy\_JohnsonHughes  
**Sent:** 01/04/2011 11:27 AM EST  
**To:** Cynthia Stahl  
**Cc:** Alan Cimorelli; dave\_stout@fws.gov; (b) (6) dhartos@osmre.gov; Jennifer Fulton; Stephanie Fulton; Walt Galloway; Ross Geredien; Matthew Klasen; (b) (6); Jessica Martinsen; Christine Mazzarella; (b) (6); tgalya@osmre.gov; (b) (6)  
**Subject:** Re: Access to materials for the Surface mining analysis -- Federal Partners

Thank you, Cynthia.

One of our tasks is to align cumulative impact analyses across the agencies. It seems like MIRA could serve as the framework that would bring together other cumulative impact assessments. MIRA is the decision making framework that uses actual data and modeled data. Using this idea, a decision maker/project reviewer could input actual data collected by a project proponent, model results for critical parameters, results from OSM CHIA, results from the COE HGM, and results from FRAMES into MIRA. USGS and Passmore & Pond data sets would provide actual data for a site and data for the models to help predict the relative change due to an impact.

If this is followed, then we can identify the data that needs to be collected by the project proponent and reduce overlap amongst the various agencies' assessments. For example, data needed for the CHIA could be used (at least in part) for the HGM and as actual data for MIRA. Then we need to review data used by each assessment to find overlaps and see what each assessment provides (since each one covers a different perspective). We may need additional models to cover those not already included in an assessment.

Is this what was proposed during our last meeting?

Christy Johnson-Hughes

\*\*\*\*\*

National Energy Coordinator  
Coal Mining, Oil & Gas, Nuclear and Wind  
Div of Habitat and Resource Conservation  
Branch of Conservation Planning Assistance  
U.S. Fish and Wildlife Service  
4401 N. Fairfax Drive, Rm 840C  
Arlington, VA 22203  
703/358-1922  
703/358-1869 fax

**Stahl.Cynthi  
a@epamail.e  
pa.gov**

01/03/2011

06:19 PM

To Cimorelli.Alan@epamail.epa.gov, Bergdale.Amy@epamail.epa.gov, Schaller.Andrea@epamail.epa.gov, Williams.AshleyL@epamail.epa.gov, Okorn.Barbara@epamail.epa.gov, Rudnick.Barbara@epamail.epa.gov, Jenkins.Bill@epamail.epa.gov, Mazzarella.Christine@epamail.epa.gov, Hunter.Christopher@epamail.epa.gov, Rader.Cliff@epamail.epa.gov, Holliman.Daniel@epamail.epa.gov, Rider.David@epamail.epa.gov, Poole.Elizabeth@epamail.epa.gov, Somerville.Eric@epamail.epa.gov, Pond.Greg@epamail.epa.gov, kremer.janet@epamail.epa.gov, lapp.jeffrey@epamail.epa.gov, Fulton.Jennifer@epamail.epa.gov, Martinsen.Jessica@epamail.epa.gov, forren.john@epamail.epa.gov, Pomponio.John@epamail.epa.gov, Gillespie.Joy@epamail.epa.gov, McCarthy.Julia@epamail.epa.gov, babendreier.justin@epamail.epa.gov, Wright.Justin@epamail.epa.gov, Markiewicz.Karl@epamail.epa.gov, Miller.KevinH@epamail.epa.gov, DeNardi.Kristopher@epamail.epa.gov, Werner.Lora@epamail.epa.gov, passmore.margaret@epamail.epa.gov, Douglas.Mark@epamail.epa.gov, Nicholson.Matt@epamail.epa.gov, Klasen.Matthew@epamail.epa.gov, Lee.Matthew@epamail.epa.gov, Dunn.Michael@epamail.epa.gov, Paiste.Richard@epamail.epa.gov, Geredien.Ross@epamail.epa.gov, Beers.Samantha@epamail.epa.gov, Manoyan.Simon@epamail.epa.gov, Fulton.Stephanie@epamail.epa.gov, Spielberger.Susan@epamail.epa.gov, galloway.walt@epamail.epa.gov, melgin.wendy@epamail.epa.gov, cbailey@osmre.gov, tgalya@osmre.gov, dhartos@osmre.gov, (b) (6), Christy\_JohnsonHughes@fws.gov (b) (6)  
dave\_stout@fws.gov (b) (6), (b) (6)

cc

Su Access to materials for the Surface mining analysis -- Federal Partners

bje

ct

Dear All, I'm slowly getting organized after the holidays. Attached you will find instructions for the EPA Science Connector where I've established a project page called MTM Indicators for the purpose of providing all federal partners access to common materials (without clogging up our Inboxes). Let me know if you have any questions or any trouble with this. Thanks. Cynthia

Cynthia H. Stahl, Ph.D.  
Environmental Scientist  
phone: 215-814-2180  
fax: 215-814-5718  
email: stahl.cynthia@epa.gov

Mailing address:

3EA10

U.S. Environmental Protection Agency Region III

1650 Arch Street

Philadelphia, PA 19103[attachment "Instructions for joining the EPA Science Connector.docx" deleted by Christy JohnsonHughes/ARL/R9/FWS/DOI]



**Brian Topping/DC/USEPA/US**

01/06/2011 10:16 AM

To Jeffrey Lapp, Jessica Martinsen

cc Christopher Hunter, Brian Frazer, Marcel Tchaou, Ross Geredien

bcc

Subject Spring Branch Deep Mine

Jeff and Jessica,

It would be good to have a one page briefing sheet on this project by Wednesday of next week so we can get the necessary people to review and sign off on this project quickly.

Let us know if you have questions.

Thanks,

Brian

---

Brian Topping

US Environmental Protection Agency

Wetlands Division, Room 7231

Office: 202-566-5680, FAX: 202-566-1375

Mail Code 4502T, 1200 Pennsylvania Avenue, NW, Washington, DC 20460

Deliveries: EPA West -- Room 7231-S, 1301 Constitution Avenue, NW, Washington, DC 20004

topping.brian@epa.gov

---

Jeffrey Lapp

----- Forwarded by Jeffrey Lapp/R3/USEPA/US o...

12/21/2010 12:29:29 PM

From: Jeffrey Lapp/R3/USEPA/US  
To: Brian Topping/DC/USEPA/US@EPA, Christopher Hunter/DC/USEPA/US@EPA  
Date: 12/21/2010 12:29 PM  
Subject: Fw: CCIR for Spring Branch (UNCLASSIFIED)

---

----- Forwarded by Jeffrey Lapp/R3/USEPA/US on 12/21/2010 12:29 PM -----

From: "Mullins, Ginger LRH" (b) (5)  
To: Jeffrey Lapp/R3/USEPA/US@EPA  
Cc: Jessica Martinsen/R3/USEPA/US@EPA, "Taylor, Mark A LRH" (b) (5)  
Date: 12/17/2010 12:43 PM  
Subject: Fw: CCIR for Spring Branch (UNCLASSIFIED)

---

Jeff,

This email is written to respectfully request the 60 day clock to begin for the proposed Spring Branch Deep Mine in Mingo County, WV. Details are below. Thank you very much. I hope you and Jess have a wonderful Christmas and a Happy New Year!

Sincerely,  
Ginger

----- Original Message -----

From: Taylor, Mark A LRH  
To: Mullins, Ginger LRH  
Sent: Fri Dec 17 09:28:20 2010

Subject: CCIR for Spring Branch (UNCLASSIFIED)

Classification: UNCLASSIFIED

Caveats: FOUO

Ginger,

Here is the CCIR for Spring Branch, I also pasted in email. Short of it: temp (5yrs) deep mine face up and operational area; 871 lf or impact; mitigation reconstruction of stream and ILF for temporal loss.

Do you want a bigger Executive Summary for USEPA notification?

Thanks

Mark

Type: Mining NWP 50

District: LRH

State: WV

Action: ECP 60 day notification to USEPA

- a. Applicant name: Consol of Kentucky
- b. ORM application number: LRH-2009-428-TUG
- c. Mine name and location: Spring Branch No. 3 Deep Mine
  - i. County: Mingo
  - ii. Watershed: Left Fork of Riffe Branch
  - (TUG)
  - iii. Congressional District: Rahall
- d. Proposed impacts to waters of the U.S.: The applicant proposes to construct a deep mine face up and operational area temporarily (5 years) impacting 871 linear feet of stream.
- e. Key issues, if any: ECP meeting held 2/16/10, USEPA expressed no concerns. SMCRA was pending until recently (reason for delay in permit decision).
- f. Date permit decision will be made: Starting the 60 day clock on 12/17/10.
- g. Talking points for chain of command
  - i. General regional talking points: deep mine area, not a lot concern other than it is on ECP list.
  - ii. Project specific talking points:
    - Impacts: 871 linear feet of stream.
    - Compensatory Mitigation: On-site reconstruction of 871 linear feet of stream and \$104,520 payment to the WVILF Program for temporal loss.
- h. List of District POCs
  - i. Regulatory Specialist: Samantha Dailey
  - ii. Responsible Regulatory Chief: Ginger Mullins
  - iii. Signatory Level: Section Chief
  - (Mark Taylor)
  - iv. Public Affairs POC : Peggy Noel

Classification: UNCLASSIFIED  
Caveats: FOUO

[attachment "CCIR Spring Branch #3 Deep Mine.doc" deleted by Brian  
Topping/DC/USEPA/US]

Matthew  
Klasen/DC/USEPA/US  
01/19/2011 09:21 AM

To Elaine Suriano  
cc Timothy Landers, Justin Wright, Brian Frazer, MichaelG Lee,  
Sharmin Syed, Js Wilson, Ross Geredien  
bcc  
Subject Fw: Chapter available on SharePoint

Hi Elaine,

Just wanted to follow up on this note from John Craynon last week on Chapter 4 of the EIS (and copy a few other folks who may want to participate in the review process). Brian, I'm copying you on this given Tim being out, and I assume Ross would be the right person to help review this?

Attached is chapter 4 (retrieved from the Sharepoint site) as well as the comment form. (b) (5)

Elaine, do we have a deadline from OSM by which they need our comments? I can't find a date on the Sharepoint site anywhere or in John's email, and I don't think OSM mentioned a date at last month's CEO meeting.

ATTACHMENTS REDACTED--DELIBERATIVE

Thanks,  
Matt



EIS Comment form - Chapter 4 - mk.docx EIS - Chapter 4 - First Working Draft 1-12-11.pdf

-----  
Matt Klasen  
U.S. Environmental Protection Agency  
Office of Water (IO)  
202-566-0780  
cell (202) 380-7229

----- Forwarded by Matthew Klasen/DC/USEPA/US on 01/19/2011 09:16 AM -----

From: "Craynon, John" <jcraynon@osmre.gov>  
To: "Craynon, John" <jcraynon@osmre.gov>, "JohnsonHughes, Christy" <christy\_johnsonhughes@fws.gov>, "Bright, Larry" <larry\_bright@fws.gov>, Justin Wright/DC/USEPA/US@EPA, Timothy Landers/DC/USEPA/US@EPA, Matthew Klasen/DC/USEPA/US@EPA, Elaine Suriano/DC/USEPA/US@EPA  
Cc: (b) (6) "Russell.Young@usdoj.gov" <Russell.Young@usdoj.gov>, "Patrice.Simms@usdoj.gov" <Patrice.Simms@usdoj.gov>, (b) (6) "Desiree.L.Hann@usace.army.mil" <Desiree.L.Hann@usace.army.mil>, "Pizarchik, Joseph G" <JPizarchik@osmre.gov>, "Owens, Glenda H." <gowens@osmre.gov>, "Sylvester, Cheryl" <Cheryl.Sylvester@sol.doi.gov>, "Boling, Ted A" <Edward\_A\_Boling@ios.doi.gov>, "Sloanhoffer, Nancy E." <nsloanhoffer@osmre.gov>, "Varvell, Stephanie L." <svarvell@osmre.gov>, "Barchenger, Ervin" <ebarchenger@osmre.gov>, "Klein, Al" <Aklein@osmre.gov>, "Shope, Thomas D. \"Tom\"" <tshope@osmre.gov>, "Winters, William R. \"Bill\"" <bwinters@osmre.gov>, "Uranowski, Lois J." <luranowski@osmre.gov>, "Shawley, Dianne M" <dshawley@osmre.gov>, "Ishee, Mary Katherine" <mkishee@osmre.gov>, "Rideout, Sterling" <srideout@osmre.gov>, "Davis, Vermell" <Vermell\_Davis@ios.doi.gov>, "Rideout, Sterling" <srideout@osmre.gov>  
Date: 01/13/2011 11:26 AM  
Subject: Chapter available on SharePoint

**REMEMBER, THIS EIS IS A DRAFT / PRE-DECISIONAL DOCUMENT AND IS INTENDED FOR OFFICIAL USE ONLY**

Cooperating Agency and Internal Reviewers.

This email is to inform you that draft Chapter 4 documents have been posted on the OSM SharePoint site and available for your immediate review.

The following link will take you to the SharePoint site. (b) (5)

If you have any access problems please bring them to the attention of Cathy McNish in OSM's Western Region Office. Cathy's phone number and email are 303-293-5074 and [CMcNish@osmre.gov](mailto:CMcNish@osmre.gov)

Please let me know if you have any questions. I've also attached the necessary form to gain access to the site, in case you have not already made those arrangements.

John R. Craynon, P.E.  
OSM SPR EIS Team Lead  
Office of Surface Mining Reclamation and Enforcement  
Washington, DC  
202-208-2866  
202-617-5002 cell  
202-219-3276 fax  
[jcraynon@osmre.gov](mailto:jcraynon@osmre.gov)

*"For Official Use Only -- Deliberative Process Material"*



Sharepoint - AccessForm (3).doc

ATTACHMENT REDACTED--DELIBERATIVE

"Taylor, Mark A LRH"

(b) (5)

01/25/2011 09:25 AM

To "Alt, Larry M", "Borth, William C.", "Boyles, Dennis L.", "Brugess, Juddie D", "Campbell, Benny H", "Clarke, Thomas L", "Cline, Brenda J", "DLL-CELRH-OR-FE", Jennifer Fulton, "Haberman, Marcia H LRP", "Halstead, Lewis A", "Holstine, Mark D", "Hunter, Russ M", "Jessica Greathouse", Jim\_Zelenak, "Justice, Timothy D", Jeffrey Lapp, Margaret Passmore, Jessica Martinsen, "Mertz, Michael F", "Moore, Randall E", "Mullins, Ginger LRH", "Parsons, Mark J", "Porterfield, Keith O", "Ramey, Terry D", "Ross, Joseph", "Roy, Richard M", "Scott, John W", "Stottlemeyer, Dennis O", "Taylor, Mark A LRH", "Wiles, Loren B", "Wood, Thomas E", "Wright, Clarence E"

cc

bcc

Subject FW: February Pre-App Meetings (UNCLASSIFIED)

1 attachment



February 11 Pre-App Agenda.doc

ATTACHMENT REDACTED--DELIBERATIVE

Classification: UNCLASSIFIED

Caveats: NONE

Group,

I have heard from a couple of people on the list that they never received the first email. So here we go again. Also, Pocahontas Coal has canceled the 2pm meeting on the February 1st.

Sorry for the late notice if you never received the first email.

Thanks,

Mark

-----Original Message-----

From: Taylor, Mark A LRH

Sent: Friday, January 14, 2011 12:47 PM

To: 'Alt, Larry M'; 'Borth, William C.'; 'Boyles, Dennis L.'; Brugess, Juddie D; 'Campbell, Benny H'; 'Clarke, Thomas L'; 'Cline, Brenda J'; DLL-CELRH-OR-FE; Fulton, Jennifer; Haberman, Marcia H LRP; 'Halstead, Lewis A'; 'Holstine, Mark D'; 'Hunter, Russ M'; 'Jessica Greathouse'; 'Jim\_Zelenak@fws.gov'; 'Justice, Timothy D'; 'Lapp.Jeffrey@epamail.epa.gov'; Maggie Passmore; 'Martinsen.Jessica@epamail.epa.gov'; 'Mertz, Michael F'; 'Moore, Randall E'; Mullins, Ginger LRH; 'Parsons, Mark J'; 'Porterfield, Keith O'; 'Ramey, Terry D'; 'Ross, Joseph'; 'Roy, Richard M'; 'Scott, John W'; 'Stottlemeyer, Dennis O'; Taylor, Mark A LRH; 'Wiles, Loren B'; Wood, Thomas E; 'Wright, Clarence E'

Subject: February Pre-App Meetings (UNCLASSIFIED)

Classification: UNCLASSIFIED

Caveats: NONE

Attached is the meeting schedule for February.

Jessica I could not get Dr. Petty in the afternoon, however if he only needs an hour, he can start his part at 10:30.

Thanks

Mark A. Taylor  
Supervisory Biologist  
Energy Resource Section  
Huntington District Corps of Engineers

(b) (6)

Classification: UNCLASSIFIED  
Caveats: NONE

Classification: UNCLASSIFIED  
Caveats: NONE

Christine  
Mazzarella/R3/USEPA/US  
11/18/2010 06:46 AM

To: Jeffrey Lapp  
cc  
bcc  
Subject: Fw: MTM Check In at CEQ

fyi...

----- Forwarded by Christine Mazzarella/R3/USEPA/US on 11/18/2010 06:46 AM -----

From: Cliff Rader/DC/USEPA/US  
To: pomponio.john@epa.gov, Bill Jenkins/R3/USEPA/US@EPA, Michael Dunn/R3/USEPA/US@EPA, Christine Mazzarella/R3/USEPA/US  
Cc: Susan Bromm/DC/USEPA/US@EPA  
Date: 11/17/2010 04:52 PM  
Subject: Fw: MTM Check In at CEQ

(b) (5)

----- Forwarded by Cliff Rader/DC/USEPA/US on 11/17/2010 04:51 PM -----

From: Susan Bromm/DC/USEPA/US  
To: Cliff Rader/DC/USEPA/US@EPA  
Date: 11/17/2010 10:48 AM  
Subject: Fw: MTM Check In at CEQ

This message is being sent via Blackberry. Please excuse typos.  
Linda Huffman

----- Original Message -----

**From:** Linda Huffman  
**Sent:** 11/17/2010 09:07 AM EST  
**To:** Susan Bromm  
**Subject:** Fw: MTM Check In at CEQ

FYI - Cynthia will be attending this meeting at CEQ

Linda Huffman  
Executive Assistant  
U.S. EPA  
Office of Enforcement and Compliance Assurance  
202-564-2440

----- Forwarded by Linda Huffman/DC/USEPA/US on 11/17/2010 09:07 AM -----

### Calendar Entry

Type: Meeting  
Chair: Cynthia Giles-AA/DC/USEPA/US  
Sent By: Linda Huffman/DC/USEPA/US

☐ Mark Private  
☐ Mark Available



**Subject:** MTM Check In at CEQ

**When:**

Starts:	Tue 12/07/2010	02:30 PM	Local time	
Ends:	Tue 12/07/2010	03:30 PM	Local time	1 hour
This entry does not repeat				

**Who:**

**Where:** Location: 722 Jackson Place

#### Description

Hello everyone,

The next mountaintop mining check-in will be held on **Tuesday, December 7<sup>th</sup>** from 2:30-3:30 pm at CEQ in 722 Jackson Place. We will send a draft agenda to the full group prior to the meeting.

Please confirm your attendance for the meeting with Lauren Leuck at (b) (6) or (b) (6).

Also, I wanted to provide you all with an update on the Appalachian Regional Development Initiative. Eight Federal agencies have joined the Appalachian Regional Commission and signed an MOU to bolster interagency collaboration in strengthening and diversifying the Appalachian economy. Please visit the website for the Commission at <http://www.arc.gov/> for additional information.

Thank you again for all of your hard work and continued progress on our commitments.

All the best,  
Mike

Michael Boots  
Associate Director for Land and Water Ecosystems  
White House Council on Environmental Quality  
730 Jackson Place NW  
Washington, DC 20530  
Main Line: 202-456-6224  
Direct: (b) (6)



**Jim\_Zelenak@fws.gov**

11/01/2010 01:41 PM

To David Rider

cc

bcc

Subject Fw: it's friday, it must be time for...Spruce References!

1 attachment



pic18935.gif

Dave,

I just left you a voice message - this is follow-up. Please see the email you sent me on 9/21 at 3:49 pm. Near the bottom, it includes a message from Palmer to FWS's Jack Arnold, initiating the sec 7 ESA process for the Yazoo Recommended Determination (RD). You could just change the language in that message so that it addresses the Spruce RD, and email it to me (or to Deborah Carter and cc me).

Let me know if you can do that. I'm trying to have this letter ready to send to our Regional Office by tomorrow COB, so if you could get that email out today or early tomorrow, that would be a big help.

Thanks,

Jim Zelenak  
U.S. Fish and Wildlife Service  
West Virginia Field Office  
694 Beverly Pike  
Elkins, WV 26241  
ph: (304) 636-6586 X 17  
fax: (304) 636-7824  
jim\_zelenak@fws.gov

----- Forwarded by Jim Zelenak/R5/FWS/DOI on 11/01/2010 01:37 PM -----

**Jim  
Zelenak/R5/FWS/  
DOI**

10/29/2010 06:07  
PM

ToRider.David@epamail.epa.gov

ccDeb Carter/R5/FWS/DOI@FWS, Laura  
Hill/R5/FWS/DOI@FWS

SubjectRe: Fw: it's friday, it must be time for...Spruce  
References!

Hi Dave,

Just left you a voice message; must have just missed you. The citation you present below does not look familiar to me off-hand. I did learn recently that our Contaminants Biologist, who works out of Wheeling and whose name I can't recall at the moment, also supplied some information. Perhaps she submitted the citation in question? I can try to track that down next week if you don't have any luck doing so.

On another note, I've finally had a chance to spend some time reviewing the Recommended Determination and to start drafting the two pieces of correspondence EPA has requested. For the section 7 letter, it occurred to me that I have not seen initiating correspondence from EPA to get the consultation process rolling. Typically, we receive a letter from an action agency describing the proposed activity, a brief rationale for their conclusion that the action will not affect any federally-listed threatened or endangered species or their designated critical habitats, and a request for the Service's concurrence with their conclusion.

Our section 7 letter is usually in response to that initiating request. I'm not sure if such a letter was sent from EPA to FWS at a different level, but I have not seen anything other than your email request and the other messages it generated. If such a letter has gone out, could you please forward a copy to me? If no such letter has gone out, you may need to draft one. Again, it can be very brief, from EPA Region III to the West Virginia Field Office (addressed to Deborah Carter, Field Supervisor, at the address below), requesting that the Service concur with your determination that the proposed activity will not affect T&E species or designated habitats.

Also, could you please provide me with the date that the Recommended Determination was released? I couldn't find one on the EPA link you sent me via email on Oct. 20, on the document itself, or elsewhere on EPA's website.

Once we have those bits of correspondence/information, we plan to have both letters drafted early next week and begin moving them through Regional Office and Washington Office for review/signatures.

Let me know if you have questions.

Jim Zelenak  
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West Virginia Field Office  
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▼ Rider.David@epamail.epa.gov

**Rider.David@epamail.epa.gov**

Tojim\_Zelenak@fws.gov

10/29/2010 05:05  
PM

ccTraver.Carrie@epamail.epa.gov

SubjectFw: it's friday, it must be time for...Spruce  
References!

Jim,

Do you have a copy of this reference needed for the Spruce RD  
package.

These are on the reference list, but I need a copy:

- USFWS unpublished data 2005 (about White Oak Branch survey)  
(p30)

Dave

----- Forwarded by David Rider/R3/USEPA/US on 10/29/10 05:02 PM  
-----

it's friday, it must be time for...Spruce References!

Carrie Traver

to:

Louis                      Greg Pond, Margaret Passmore, Frank Borsuk,  
                             Reynolds

04:41 PM

10/29/10

Cc:

David Rider, Regina Poeske

(b) (5) [REDACTED]  
[REDACTED]  
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[REDACTED]

[REDACTED]  
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[REDACTED]

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(b) (5)

let me know.

Thanks for the response!  
Carrie

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1650 Arch Street - 3EA30  
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traver.carrie@epa.gov

"Rice, Dennis"  
<drice@osmre.gov>  
11/18/2010 04:05 PM

To: Matthew Klasen  
cc  
bcc  
Subject: RE: SPR

1 attachment



ATTACHMENT REDACTED-DELIBERATIVE

Summary of comments from other agencies 11-02-10.docx

Here's my unofficial summary list of comments that I think may require further discussion or elevation, in case it's of any help to you.

Dennis

**From:** Klasen.Matthew@epamail.epa.gov [mailto:Klasen.Matthew@epamail.epa.gov]  
**Sent:** Thursday, November 18, 2010 3:57 PM  
**To:** Rice, Dennis  
**Subject:** Re: Permit defects

OK, thanks for your help. (b) (5)

Thanks,  
Matt

---

Matt Klasen  
U.S. Environmental Protection Agency  
Office of Water (IO)  
202-566-0780  
cell (202) 380-7229

From: "Rice, Dennis" <drice@osmre.gov>  
To: Matthew Klasen/DC/USEPA/US@EPA  
Date: 11/18/2010 03:53 PM  
Subject: Permit defects

---



Matt,

Apparently the signed documents to which you referred are still working their way through the distribution system. (b) (5)

I'll

send you the document when I receive it.

Dennis

"Shawley, Dianne M"  
<dshawley@osmre.gov>  
11/24/2010 10:38 AM

To Nancy Stoner  
cc "Pizarchik, Joseph G"  
bcc  
Subject EPA's comments on the SPR

1 attachment



ATTACHMENT REDACTED--DELIBERATIVE

EPA comments on surface and general SPR text 11-02-10.docx

Hi Nancy - We really appreciated your coming to meet with us yesterday. The Director thought the discussion went very well and we are sorry that we didn't have more time to spend on these important issues. You mentioned that you would provide us with a copy of EPA's redline version of comments on the Stream Protection Rule. Please take a look at the attached document. I think this may be the same version that you and Greg were referring to in the meeting. If so, then no need to resend. If not, could you please provide us with the updated document? Thank you again for making the trip across town. Have a wonderful Thanksgiving.

I am sure we will be in touch!  
Best,  
Dianne

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Counsel to the Director  
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Office of Surface Mining

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South Interior Building, Room 235  
Washington, D.C. 20240

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Fax: (202) 219-3106  
DShawley@osmre.gov

"Leuck, Lauren"

(b) (6)

12/28/2010 04:32 PM

To Matthew Klasen

cc

bcc

Subject RE: FYI -- updated draft SAB review reports on MTM available online (telecon scheduled Jan. 19)

Hi Matt,

Thank you for the update. I have not heard yet from Maggie when the next MTM check-in will be (b) (6)

(5)

I hope you had a great holiday!

Best,  
Lauren

**From:** Klasen.Matthew@epamail.epa.gov [mailto:Klasen.Matthew@epamail.epa.gov]

**Sent:** Tuesday, December 28, 2010 4:24 PM

**To:** Leuck, Lauren

**Subject:** Fw: FYI -- updated draft SAB review reports on MTM available online (telecon scheduled Jan. 19)

Hey Lauren,

Hope you're enjoying either some time off or a fairly light work week!

FYI below for an update on the SAB review process. I suspect we'll send out a note to the interagency group the week of the 10th letting everyone know about the SAB call and providing the call-in number. We can also report back at the January monthly meeting, as appropriate.

Following the discussion on the 19th, the SAB will make appropriate revisions to these reports (typically, revisions are minor at this stage of the process). At that point, the SAB finalizes its reports and transmits them to the Administrator, thereby completing its review.

Best,  
Matt

-----  
Matt Klasen  
U.S. Environmental Protection Agency  
Office of Water (IO)  
202-566-0780  
cell (202) 380-7229

----- Forwarded by Matthew Klasen/DC/USEPA/US on 12/28/2010 04:16 PM -----

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Matthew Klasen/DC/USEPA/US

T Gregory Peck/DC/USEPA/US@EPA, Brian Frazer/DC/USEPA/US@EPA, David Evans/DC/USEPA/US@EPA, Christopher  
o Hunter/DC/USEPA/US@EPA, Jim Pendergast/DC/USEPA/US@EPA, Brian Topping/DC/USEPA/US@EPA, Ross  
: Geredien/DC/USEPA/US@EPA, Sharmin Syed/DC/USEPA/US@EPA, Js Wilson/DC/USEPA/US@EPA, Marcus  
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Suter/CI/USEPA/US@EPA

D  
a 12/28/2010 03:08 PM  
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S FYI -- updated draft SAB review reports on MTM available online (telecon scheduled Jan. 19)

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Hi everyone,

ORD let us know a few minutes ago that the SAB has posted updated draft reports on both of the ORD  
MTM reports (the MTM/VF impacts report, and the conductivity benchmark report).

The SAB drafts are available at  
[http://yosemite.epa.gov/sab/SABPRODUCT.NSF/MeetingCal/ED55AF1742315D34852577EC0059AADC  
?OpenDocument](http://yosemite.epa.gov/sab/SABPRODUCT.NSF/MeetingCal/ED55AF1742315D34852577EC0059AADC?OpenDocument) (definitely not the most straightforward URL). Reports are at the bottom of the page.

The full SAB will be holding a quality review teleconference on Wednesday, January 19 from noon to 3  
pm to discuss these draft reports, in preparation for forwarding the SAB's final reports to the Administrator  
early next year.

Thanks,  
Matt

-----  
Matt Klasen  
U.S. Environmental Protection Agency  
Office of Water (IO)  
202-566-0780  
cell (202) 380-7229

Ross  
Geredien/DC/USEPA/US  
12/07/2010 04:25 PM

To David Evans  
cc Brian Frazer, Brian Topping, Jim Pendergast  
bcc  
Subject Re: Fw: Conductivity -Caucus Briefing papers  
(UNCLASSIFIED)

Brian, I'll double-check with you, but I believe this is it:



CONDUCTIVITY\_REPORT\_ERD[1].pdf

Ross Geredien  
ORISE Fellow  
EPA Office of Wetlands, Oceans, and Watersheds  
202-566-1466  
Geredien.ross(AT)epa.gov

David Evans

[I think its posted on-line, and expect Brian\(s\) or...](#)

12/07/2010 04:13:41 PM

From: David Evans/DC/USEPA/US  
To: Jim Pendergast/DC/USEPA/US@EPA  
Cc: Brian Frazer/DC/USEPA/US@EPA, Brian Topping/DC/USEPA/US@EPA, Ross  
Geredien/DC/USEPA/US@EPA  
Date: 12/07/2010 04:13 PM  
Subject: Re: Fw: Conductivity -Caucus Briefing papers (UNCLASSIFIED)

I think its posted on-line, and expect Brian(s) or Ross will have that info.

Dave

David Evans, Director  
Wetlands Division  
Office of Wetlands, Oceans and Watersheds  
(202) 566-0535

Jim Pendergast

[Do we have a copy of the ORD report that reco...](#)

12/07/2010 02:04:22 PM

From: Jim Pendergast/DC/USEPA/US  
To: David Evans/DC/USEPA/US@EPA  
Date: 12/07/2010 02:04 PM  
Subject: Re: Fw: Conductivity -Caucus Briefing papers (UNCLASSIFIED)

(b) (5)

David Evans

[FYI, I also just shared with Brian. David Evans,...](#)

12/07/2010 12:53:10 PM

From: David Evans/DC/USEPA/US  
To: Jim Pendergast/DC/USEPA/US@EPA  
Date: 12/07/2010 12:53 PM  
Subject: Fw: Conductivity -Caucus Briefing papers (UNCLASSIFIED)

FYI, I also just shared with Brian.

David Evans, Director  
Wetlands Division  
Office of Wetlands, Oceans and Watersheds  
(202) 566-0535

----- Forwarded by David Evans/DC/USEPA/US on 12/07/2010 12:53 PM -----

From: "Gaffney-Smith, Margaret E" (b) (6)  
To: David Evans/DC/USEPA/US@EPA  
Cc: "Hann, Desiree L LRH" (b) (6), "James, William L LRN"  
(b) (6), "Cofrancesco, Al F ERDC-EL-MS"  
(b) (6), "Mulligan, Karen C HQ02"  
(b) (6)  
Date: 12/07/2010 12:06 PM  
Subject: FW: Conductivity -Caucus Briefing papers (UNCLASSIFIED)

---

Classification: UNCLASSIFIED

Caveats: FOUO

Dave,

Attached are documents related to the presentation provided by Steve Canton at the Coal Caucus briefing.

Meg Gaffney-Smith  
Chief, Regulatory Community of Practice  
HQUSACE

(b) (6)

-----Original Message-----

From: Bennett,Karen [mailto:KBennett@nma.org]  
Sent: Tuesday, December 07, 2010 12:03 PM  
To: Gaffney-Smith, Margaret E; Peck.Gregory@epamail.epa.gov  
Subject: Conductivity -Caucus Briefing papers

I am sending the attached on behalf of Steve Canton. I understand he agreed to send them following the Coal Caucus briefing last week. These are the two documents Steve prepared for the briefing.

It was nice seeing both of you last week

Karen

Classification: UNCLASSIFIED

Caveats: FOUO

[attachment "Primary Technical Concerns with Proposed EPA Conductivity Benchmark.pdf" deleted by Jim Pendergast/DC/USEPA/US] [attachment "EPA WQ

criteria development methods - supplemental information.pdf" deleted by Jim  
Pendergast/DC/USEPA/US]

DRAFT  
DO NOT CITE OR QUOTE

EPA/600/R-10/023A  
March 2010  
External Review Draft



# A Field-based Aquatic Life Benchmark for Conductivity in Central Appalachian Streams

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National Center for Environmental Assessment  
Office of Research and Development  
U.S. Environmental Protection Agency  
Washington, DC 20460



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### **Preferred Citation:**

U.S. EPA (Environmental Protection Agency). 2010. A Field-based Aquatic Life Benchmark for Conductivity in Central Appalachian Streams. Office of Research and Development, National Center for Environmental Assessment, Washington, DC. EPA/600/R-10/023A.

## CONTENTS

LIST OF TABLES .....	v
LIST OF FIGURES .....	vi
LIST OF ABBREVIATIONS AND ACRONYMS .....	vii
AUTHORS, CONTRIBUTORS, AND REVIEWERS .....	viii
ACKNOWLEDGMENTS .....	xi
EXECUTIVE SUMMARY .....	xii
1. INTRODUCTION .....	1
1.1. CONDUCTIVITY .....	1
1.2. APPROACH .....	2
2. DATA SETS .....	5
2.1. DATA SET SELECTION.....	5
2.2. DATA SOURCES .....	5
2.3. DATA SET CHARACTERISTICS.....	6
3. METHODS .....	8
3.1. EXTIRPATION CONCENTRATION DERIVATION .....	8
3.2. TREATMENT OF POTENTIAL CONFOUNDERS.....	10
3.3. DEVELOPING THE SPECIES SENSITIVITY DISTRIBUTION .....	11
3.4. CONFIDENCE BOUNDS.....	11
3.5. ESTIMATING BACKGROUND.....	12
4. RESULTS .....	13
4.1. EXTIRPATION CONCENTRATIONS.....	13
4.2. SPECIES SENSITIVITY DISTRIBUTIONS .....	13
4.3. HAZARDOUS CONCENTRATION VALUES AT THE 5 <sup>th</sup> PERCENTILE .....	13
4.4. UNCERTAINTY ANALYSIS .....	13
5. CONSIDERATIONS.....	15
5.1. SELECTION OF INVERTEBRATE GENERA .....	15
5.2. SEASONALITY, LIFE HISTORY, AND SAMPLING METHODS.....	15
5.3. INCLUSION OF REFERENCE SITES .....	16
5.4. DEFINING THE REGION OF APPLICABILITY .....	16
5.5. BACKGROUND .....	17
5.6. INCLUSION OF OTHER TAXA .....	17
5.7. TREATMENT OF RARE SPECIES .....	17
5.8. SELECTION OF THE EFFECTS ENDPOINT .....	18
5.9. USE OF MODELED OR EMPIRICAL DISTRIBUTIONS .....	18
5.10. TREATMENT OF CAUSATION .....	19
5.11. TREATMENT OF MIXTURES.....	19

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## CONTENTS (continued)

6. AQUATIC LIFE BENCHMARK .....	20
REFERENCES .....	21
APPENDIX A: CAUSAL ASSESSMENT .....	41
APPENDIX B: CONFOUNDING.....	66
APPENDIX C: EXTIRPATION CONCENTRATION VALUES FOR INVERTEBRATES.....	94
APPENDIX D: GRAPHS OF OBSERVATION PROBABILITIES AND CUMULATIVE DISTRIBUTION FUNCTIONS FOR EACH GENUS .....	101
APPENDIX E: VALIDATION OF METHOD USING FIELD DATA TO DERIVE AMBIENT WATER QUALITY BENCHMARK FOR CONDUCTIVITY USING KENTUCKY DATA SET .....	157
APPENDIX F: DATA SOURCES AND METHODS OF LANDUSE/LAND COVER ANALYSIS USED TO DEVELOP EVIDENCE OF SOURCES OF HIGH CONDUCTIVITY WATER.....	170

## LIST OF TABLES

1.	Summary statistics of the measured water quality parameters .....	24
2.	Number of samples with reported genera and conductivity meeting our acceptance criteria for calculating the benchmark value.....	26
3.	Genera excluded from 95 <sup>th</sup> percentile extirpation concentration calculation because they never occurred at reference sites .....	26
4.	Hazardous concentration at the 5 <sup>th</sup> percentile for invertebrates in Ecoregions 69 and 70.....	26

## LIST OF FIGURES

1.	Data are from Tier III Ecoregions 69 and 70 spanning the states of Ohio, Pennsylvania, Kentucky, Tennessee, West Virginia, and Maryland .....	27
2.	Box plot showing seasonal variation of conductivity in the reference streams of Ecoregions 69 and 70 in West Virginia from 1999 to 2006 .....	28
3.	Histogram of the frequencies of observed conductivity values in samples from Ecoregions 69 and 70 from March to October.....	28
4.	Example of a weighted CDF and the associated 95 <sup>th</sup> percentile extirpation concentration value .....	29
5.	Three typical distributions of observation probabilities .....	30
6.	The species sensitivity distribution for all year .....	31
7.	The cumulative distribution of XC <sub>95</sub> values for the 35 most sensitive genera and the bootstrap-derived means and two-tailed 95% confidence intervals.....	32
8.	Species sensitivity distribution for all year .....	33
9.	Examples of a monthly year-long stream conductivity record in a stream.....	34
10.	Correlation of conductivity values sampled from the same site in spring and summer.....	35
11a.	Anions .....	36
11b.	Cations .....	37
11c.	Dissolved metals .....	38
11d.	Total metals.....	39
11e.	Other water quality parameters.....	40

## LIST OF ABBREVIATIONS AND ACRONYMS

CDF	cumulative distribution function
DC <sub>x</sub>	depletion concentration
GLIMPSS	genus level index of most probable stream status
HC <sub>x</sub>	hazardous concentration
KDOW	Kentucky Division of Water
RBP	rapid bioassessment protocol
SSD	species sensitivity distribution
TMDL	total maximum daily load
U.S. EPA	United States Environmental Protection Agency
WABbase	Watershed Assessment Branch Data Base
WVDEP	West Virginia Department of Environmental Protection
WVSCI	West Virginia Stream Condition Index
XC <sub>x</sub>	extirpation concentration

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Greg Pond, Susan B. Norton, Teresa Norberg-King, Peter Husby, Peg Pelletier, Treda Grayson, Amy Bergdale, Candace Bauer, Brooke Todd, Lana Wood, Heidi Glick, Cris Broyles, Linda Tackett, Stacey Lewis, Bette Zwayner, and Ruth Durham helped bring this document to completion by providing comments, essential fact checking, editing, formatting, and other key activities. Statistical review of the methodology was provided by Paul White, John Fox, and Leonid Kopylev.

## EXECUTIVE SUMMARY

This report uses field data to derive an aquatic life benchmark for conductivity that may be applied to waters in the Appalachian Region that are dominated by salts of  $\text{SO}_4^{2-}$  and  $\text{HCO}_3^-$  at circum-neutral to mildly alkaline pH. This benchmark is intended to protect the aquatic life in the region. It is derived by a method modeled on the U.S. EPA's standard methodology for deriving water quality criteria. In particular, the methodology was adapted for use of field data. Field data were used because sufficient and appropriate laboratory data were not available and because high quality field data were available to relate conductivity to effects on aquatic life. This report provides scientific evidence for a conductivity benchmark in a specific region rather than for the entire United States.

The method used in this report is based on the standard methodology in that it used the 5<sup>th</sup> percentile of a species sensitivity distribution (SSD) as the benchmark value. SSDs represent the response of aquatic life as a distribution with respect to exposure. It is implicitly assumed that if the exposure level is kept below the 5<sup>th</sup> percentile of the SSD, at least 95% of species will be protected. Data analysis followed the standard methodology in aggregating species to genera and using interpolation to estimate the percentile. It differs primarily in that the points in the SSDs are extirpation concentrations (XCs) rather than median lethal concentrations ( $\text{LC}_{50}$ s) or chronic values. The XC is the level of exposure above which a genus is effectively absent from water bodies in a region. For this benchmark value, the 95<sup>th</sup> percentile of the distribution of the probability of occurrence of a genus with respect to conductivity was used as a 95<sup>th</sup> percentile extirpation concentration. Hence, this aquatic life benchmark for conductivity is expected to avoid the local extirpation of 95% of native species (based on the 5<sup>th</sup> percentile of the SSD) due to neutral to alkaline effluents containing a mixture of dissolved ions dominated by salts of  $\text{SO}_4^{2-}$  and  $\text{HCO}_3^-$ . Because it is not protective of all genera and protects against extirpation rather than reduction in abundance, this level is not fully protective of rare species or waters designated by state and federal agencies as exceptional.

This field-based method has several advantages. Because it is based on biological surveys, it is inherently relevant to the streams where the benchmark may be applied and represents the actual aquatic life use in these streams. Another advantage is that the method assesses all life stages and ecological interactions of many species. Further, it represents the actual exposure conditions for elevated conductivity in the region, the actual temporal variation in exposure, and the actual mixture of ions that contribute to salinity as measured by conductivity.

*This document is a draft for review purposes only and does not constitute Agency policy.*

The disadvantages of field data result from the fact that exposures are not controlled. As a result, the causal nature of the relationship between conductivity and the associated biological impairments must be assessed. Also, any variables that are correlated with conductivity or the biotic response may confound the relationship of biota to conductivity. Assessments of causation and confounding were performed and are presented in the appendices. They demonstrate that conductivity is a cause of impairment and the relationship between conductivity and biological responses apparently is not significantly confounded.

The chronic aquatic life benchmark value for conductivity derived from all-year data from West Virginia is 300  $\mu\text{S}/\text{cm}$ . It is applicable to parts of West Virginia and Kentucky. It is expected to be applicable to the same regions in Ohio, Pennsylvania, Tennessee, and Maryland, but data from those states have not been analyzed. It may also be appropriate for other nearby regions such as Ecoregions 67 but has only been validated for use in Ecoregions 68, 69, and 70 at this time. However, this level may not apply when the relative concentrations of dissolved ions are not dominated by salts of  $\text{SO}_4^{-2}$  and  $\text{HCO}_3^{-}$ .

# 1. INTRODUCTION

At the request of U.S. Environmental Protection Agency (U.S. EPA) Regions 3, 4, and 5, and the Office of Water, the Office of Research and Development has developed an aquatic life benchmark for conductivity that may be applied in the Appalachian Region associated with mixtures of ions dominated by salts of  $\text{SO}_4^{2-}$  and  $\text{HCO}_3^-$  anions at circum-neutral to alkaline pH. The benchmark is intended to protect the aquatic life in streams and rivers in the region. It is derived by a method modeled on the U.S. EPA's standard methodology for deriving water quality criteria (Stephen et al., 1985). In particular, the methodology was adapted for use of field data. Field data were used because sufficient and appropriate laboratory data were not available and because high quality field data were available to relate conductivity to effects on aquatic life in streams and rivers.

## 1.1. CONDUCTIVITY

Although the elements comprising the common mineral salts such as sodium chloride (NaCl) are essential nutrients, aquatic organisms are adapted to specific ranges of salinity and experience toxic effects from excess salinity. Salinity is the property of water that results from the combined influence of all disassociated mineral salts. The most common contributors to salinity in surface waters, referred to as matrix ions, are

Cations:  $\text{Na}^+$ ,  $\text{Ca}^{2+}$ ,  $\text{Mg}^{2+}$ ,  $\text{K}^+$

Anions:  $\text{Cl}^-$ ,  $\text{HCO}_3^-$ ,  $\text{CO}_3^{2-}$ ,  $\text{SO}_4^{2-}$

The salinity of water may be expressed in various ways, but the most common is *specific conductivity*. Specific conductivity (henceforth simply conductivity) is the ability of a material to conduct an electric current measured in microsiemens per centimeter ( $\mu\text{S}/\text{cm}$ ) standardized to  $25^\circ\text{C}$ . (In this report we use “conductivity” to refer to the measurement and resulting data and “salinity” to refer to the environmental property that is measured.) Currents are carried by both cations and anions—but to different degrees depending on charge and mobility. Effectively, conductivity may be considered an estimate of the ionic strength of a salt solution. A measure such as conductivity is necessary because the effects of salts are a result of exposure to all of the ions in the mixture—not to any one individually. Hence, unless an individual ion occurs at a much higher concentration relative to its toxicity than other ions, the individual ion would not be the only potential cause, and a criterion for an individual ion could be under-protective. The ionic composition of mixtures of salts affects its toxicity (Mount et al., 1997). Therefore, this

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aquatic life benchmark for conductivity is applicable for streams in the Appalachian Region where conductivity is dominated by salts of  $\text{SO}_4^{2-}$  and  $\text{HCO}_3^-$  at circum-neutral to mildly alkaline pH.

Salinity has numerous sources (Ziegler et al., 2007). Freshwater can become increasingly salty due to evaporation, which concentrates salts such as occurs with irrigation return waters (Rengasamy, 2002), or diversions that reduce inflow relative to evaporation (e.g., Pyramid Lake, Nevada). Intrusion of saltwater occurs when ground water withdrawal exceeds recharge especially near coastal areas (Bear et al., 1999; Werner, 2009). Freshwater can also become salty with the additions of brines and wastes (Clark et al., 2001), minerals dissolved from weathering rocks (Pond, 2004), and runoff from treating pavements for icy conditions (Environment Canada and Health Canada, 2001; Evans and Frick, 2000).

Exposure of aquatic organisms to salinity is direct. Fish, amphibians, mussels, and aquatic macroinvertebrates are exposed as they ventilate their gills or other respiratory surfaces in the course of taking up oxygen. The respiratory surfaces contain specific structures to actively take up nutrient ions and control the osmotic balance of organisms. However, these structures may only be able to operate within a range of salinities. For example, some aquatic insects, such as most Ephemeroptera (mayflies), have evolved in a low salt environment. Because they would normally lose salt, their cuticle is permeable to the uptake of salt, and they take up salt using specialized external chloride cells on their gills (Komnick, 1977). Also, some life stages of animals may be particularly sensitive. For instance, ionic concentrations and transport processes are essential to regulate membrane permeability during external fertilization of eggs, including those of fish (Tarin et al., 2000).

## 1.2. APPROACH

The approach used to derive the benchmark is based on the standard method for the U.S. Environmental Protection Agency's (U.S. EPA's) published Section 304(a) Ambient Water Quality Criteria. Those criteria are the 5<sup>th</sup> percentiles of species sensitivity distributions (SSDs) based upon laboratory toxicity tests, such that the goal is to protect 95% of the species in an exposed community (Stephan et al., 1985). SSDs are models of the distribution of exposure levels at which species respond to a stressor. That is, the most sensitive species responds at exposure level  $X_1$ , the second most sensitive species responds at  $X_2$ , etc. The species ranks are scaled from 0 to 1 so that they represent cumulative probabilities of responding, and the probabilities are plotted against the exposure levels (Posthuma et al., 2002). Centiles of the distribution can be derived using interpolation, parametric regression, or nonparametric regression.

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1 For the conductivity benchmark, the SSDs are derived from field data. There are several  
2 reasons that some pollutants, such as suspended and bedded sediments (U.S. EPA, 2006;  
3 Cormier et al., 2008), and some assessment endpoints do not lend themselves to laboratory  
4 testing. For example, traditional toxicity testing and the resulting criteria derivation procedures  
5 used by EPA do not allow for the study of a pollutant's effects on migration, predation, and other  
6 behaviors or for species interaction. Furthermore, toxicity tests are rarely completed for the most  
7 susceptible species and sensitive life stages, which are difficult to identify or to maintain and test  
8 in the laboratory. The result is that the criteria are derived based on toxicity tests conducted  
9 upon species that can be cultured in a laboratory setting, and these tests do not include a  
10 substantial fraction of the species inhabiting an ecosystem. In sum, SSDs based on laboratory  
11 studies cannot replicate the full range of effects or species interactions that could reasonably be  
12 expected to occur in the environment (Suter et al., 2002).

13 The choice to use field data to derive benchmarks of any kind poses some challenges.  
14 Because causal relationships in the field are uncontrolled, unreplicated, and unrandomized, they  
15 are subject to random responses and to confounding. Confounding is the appearance of  
16 apparently causal relationships that are due to noncausal correlations. In addition, noncausal  
17 correlations and the inherent noisiness of environmental data can obscure true causal  
18 relationships. The potential for confounding is reduced, as far as possible, by identifying  
19 potential confounding variables, determining their contributions, if any, to the relationships of  
20 interest, and eliminating their influence when possible and as appropriate based on credible and  
21 objective scientific reasoning (see Appendix B). In addition, the evidence for and against salts as  
22 a cause of biological impairment is weighed using causal criteria adapted from epidemiology  
23 (see Appendix A).

24 Because relationships between conductivity and biological responses appear to vary  
25 among regions and among different mixtures of ions, this benchmark is limited to two  
26 contiguous regions with a particular dominant source of salinity. The regions are Level III 69  
27 (Central Appalachian) and 70 (Western Allegheny Plateau) (see Figure 1) (U.S. EPA, 2007;  
28 Omernik, 1987; Woods et al., 1996). Low salinity rain water, sometimes so low as to not be  
29 accurately measured by conductivity, becomes salty as it interacts with the earth's surface.  
30 Along surface and ground water paths to the ocean, water contacts bare rock. The rock  
31 demineralizes and contributes salts that accumulate. A large surface to volume ratio of  
32 unweathered rock increases dissolution of rock. For the most part, these salts are not degraded  
33 by natural processes but can be diluted by more rain or by less salty tributaries. Drought  
34 increases salt concentrations. Addition of wastes or waste waters also contributes salts. The  
35 prominent sources of salts in Ecoregions 69 and 70 are mine overburden and valley fills from

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1 large scale surface mining, but they may also come from slurry impoundments, coal refuse fills,  
2 or deep mines. Other sources include effluent from waste water treatment facilities and brines  
3 from natural gas drilling and coalbed methane production. This benchmark for conductivity  
4 applies to waters influenced by current inputs from these sources in Ecoregions 69 and 70 with  
5 salts dominated by  $\text{SO}_4^{2+}$  and  $\text{HCO}_3^-$  anions at circum-neutral to mildly alkaline pH.



## 2. DATA SETS

Data are required to develop the benchmark and to support it. This section explains how the data were selected, describes the data that were used, and explains how the data set was refined to make it useful for analysis.

### 2.1. DATA SET SELECTION

The Central Appalachia (69) and Western Allegheny Plateau (70) ecoregions were selected for development of a benchmark for conductivity because available data were of sufficient quantity and quality, and because conductivity has been implicated as a cause of biological impairment in these ecoregions (Pond et al., 2008). These regions were judged to be similar in terms of water quality, including resident biota and sources of conductivity. Confidence in the quality of reference sites in West Virginia was relatively high owing to the extensively forested areas of the region and well-documented process by which West Virginia Department of Environmental Protection (WVDEP) assigns reference status. They use a tiered approach. Only tier 1 was used when analyses involved the use of reference sites, thus avoiding the use of conductivity as a characteristic of reference condition. Nevertheless, conductivity values from WVDEP's reference sites were low and similar in different years (see Figure 2), providing evidence that the sites were reasonable reference sites. The 75<sup>th</sup> percentiles were below 200  $\mu\text{S}/\text{cm}$  in most years.

### 2.2. DATA SOURCES

All data used in this study were taken from the WVDEP's in-house Watershed Assessment Branch Data Base (WABbase) 1999–2007. The WABbase contains data from Level III Ecoregions 66, 67, 69, and 70 in West Virginia (see Figure 1) (U.S. EPA, 2000; Omernik, 1987; Woods et al., 1996). Chemical, physical, and/or biological samples were collected from 3,286 distinct locations during the sampling years 1999–2007. WVDEP uses a tiered sampling design collecting measurements from long-term monitoring stations; targeted sites within watersheds on a rotating basin schedule; probability sites (Smithson, 2007); and sites chosen to further define impaired stream segments in support of total maximum daily load (TMDL) development (WVDEP, 2008b). Most sites have been sampled once during an annual sampling period, but TMDL sites have been sampled monthly for water quality parameters. Some targeted sites represent least disturbed or reference sites that have been selected by a combination of screening values and best professional judgment (Bailey, 2009). Water quality, habitat, watershed characteristics, macroinvertebrate data (both raw data and calculated metrics),

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1 and supporting information are used by the State to develop 305(b) and 303(d) reports to the  
2 U.S. EPA (WVDEP, 2008b). Quality assurance and standard procedures are described by  
3 WVDEP (2006, 2008a). All contracted analyses for chemistry and macroinvertebrate  
4 identification follow WV's internal quality control and quality assurance protocols. This is a  
5 well-documented, regulatory database. We judged the quality assurance to be excellent based on  
6 the database itself, supporting documentation, and experience of EPA Region 3 personnel.

7 Background information was also obtained from the literature and other sources for the  
8 assessments of causality and confounding (see Appendices A and B). (1) Toxicity test results  
9 were obtained from peer-reviewed literature and from the U.S. EPA's Ecological Toxicology  
10 Database. (2) Information on the effects of dissolved salts on freshwater invertebrates was taken  
11 from standard texts and other physiological reviews. (3) The original data for Table 3 in Pond et  
12 al. (2008) were obtained from the authors to evaluate the relative contribution of different ions in  
13 drainage from valley fills of large scale surface mining. (4) The constituent ions for Marcellus  
14 Shale brine were provided by EPA Region 3 based on analyses by drilling operators.

### 16 **2.3. DATA SET CHARACTERISTICS**

17 Biological sampling usually occurred once per sampling period (March through October)  
18 with the WVDEP (1996–2007) sampling protocol. Repeat biological samples from the same  
19 location were minimal and not excluded from the data set. They represented approximately 4%  
20 of the sampled sites; therefore, no correction was made for pseudoreplication. Summary  
21 statistics for ion concentration and other parameters for the data set are provided in Table 1. The  
22 benchmark applies to waters with a similar composition.

23 Data from a sampling event at a site were excluded from calculations if they lacked a  
24 conductivity measurement, for obvious reasons. They were excluded if the samples were  
25 identified as being from a large river ( $>155 \text{ km}^2$ ), because the assemblages are not comparable  
26 with wadable streams (Flotemersch et al., 2001). They were excluded if the salt mixture was  
27 dominated by  $\text{Cl}^-$  rather than  $\text{SO}_4^{2-}$  (conductivity  $>1,000 \text{ }\mu\text{S/cm}$ ,  $\text{SO}_4 <125 \text{ mg/L}$ , and  
28  $\text{Cl}^- >250 \text{ mg/L}$ ). Four sites with elevated conductivity, high chloride and low sulfate were  
29 removed in response to concerns that the benchmark might be biased by sites with salts  
30 dominated by Marcellus Shale brines.

31 Data were excluded from calculations if the organisms were not identified to the genus  
32 level, and a genus was excluded if it was never observed at reference sites or it was observed at  
33  $<30$  sampling sites. Invertebrate genera, that did not occur at WVDEP tier 1 reference sites  
34 represented 7% of the spring genera and 8% of the summer genera, were excluded from the  
35 SSDs. They were excluded so that the data would be relevant to potentially unimpaired

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1 conditions and so as to not include opportunistic salt-tolerant organisms. The exclusion of  
2 genera that were observed at fewer than 30 sampling locations in the composited ecoregion  
3 ensured reasonable confidence in the evaluation of the relationship between conductivity and the  
4 presence and absence of a genus.

5 Before identifying the extirpation concentration (e.g., 95<sup>th</sup> percentile extirpation  
6 concentration [XC<sub>95</sub>]) for each genus, we removed effects of low pH by excluding sites with a  
7 pH of <6. This prevented potential confounding of conductivity effects by the effects of acid  
8 mine drainage (see Appendix B).

9 We evaluated the effects of spring benthic invertebrate emergence, temperature, and  
10 different conductivities associated with season by partitioning the data set into spring  
11 (March–June) and summer (July–October) subsets.

12 In the WABbase, 498 benthic invertebrate genera were identified of which 213 genera  
13 occurred at the 75 reference sites in the two ecoregions (see Table 2). Genera that did not occur  
14 at reference sites were excluded from the SSD (see Table 3). Greater than 90% of genera  
15 observed at reference sites as defined by WVDEP occur in both Ecoregions 69 and 70. This  
16 indicates that the same sensitive genera exist in both ecoregions. Ecoregions 69 and 70 had  
17 304 genera in common. Of the overall 498 genera, 170 occurred at >30 sampling locations in  
18 Ecoregions 69 and 70. Of the genera occurring at >30 sampling sites, 128 genera occurred in  
19 Ecoregions 69 and 129 in Ecoregion 70.

### 3. METHODS

The derivation of the benchmark for conductivity includes three steps: First, the benchmark values (XCs) for the invertebrate genera were derived. Second, the XC<sub>95</sub> values were used to generate an SSD and the 5<sup>th</sup> percentile of the distribution, the 5<sup>th</sup> percentile hazardous concentration (HC<sub>05</sub>). (The HC<sub>X</sub> terminology for concentrations derived from SSDs is not in the 1985 U.S. EPA method, but has become common more recently [Posthuma et al., 2002]). Finally, background values were estimated for the regions to ensure that the benchmark is not in the background range. These steps are explained in this section.

Extirpation is defined as the depletion of a population to the point that it is no longer a viable resource or is unlikely to fulfill its function in the ecosystem (U.S. EPA, 2003). In this report, extirpation is operationally defined for a genus as the conductivity value below which 95% of the observations of the genus occur and above which only 5% occur. In other words, the probability is 0.05 that an observation of a genus occurs above its XC<sub>95</sub> conductivity value. This is a chronic endpoint because the field data set reflects exposure over the entire life cycle of the resident biota. The 95<sup>th</sup> percentile was selected because it is more stable than the maximum value, yet still represents the extreme of an organism's tolerance of conductivity.

#### 3.1. EXTIRPATION CONCENTRATION DERIVATION

The XC<sub>95</sub> is estimated as the 95<sup>th</sup> percentile of the cumulative distribution of probabilities of observing a genus at a site with respect to the concurrently measured conductivity at that site. The XC<sub>95</sub> estimates a conductivity value above which very few, less than 5%, of the observations of a particular genus are likely to be found.

Observed conductivity values were nonuniformly distributed across a range of possible values (see Figure 3), and, therefore, we were more likely to observe a genus at certain conductivity values simply because more samples were collected at those values. To correct for the uneven sampling frequency, we used weighted cumulative distribution functions to estimate the XC<sub>95</sub> values for each genus. The purpose of weighting is to avoid bias due to uneven distribution of observations with respect to conductivity by converting the sampling distribution to one that mimics an even distribution of sample across the gradient of conductivity. It creates a distribution more like the design of a toxicity test, which is appropriate when developing an exposure-response relationship. To compute weights for each sample, we first defined equally-sized bins, each 0.048 log conductivity units wide, that spanned the range of observed conductivity values. We then calculated the number of samples that occurred within each bin

(see Figure 3). Each sample was then assigned a weight  $w_i = 1/n_i$ , where  $n_i$  is the number of samples in the  $i^{th}$  bin.

The value of the weighted cumulative distribution function,  $F(x)$ , of conductivity values associated with observations of a particular genus was computed for each unique observed value of conductivity,  $x$ , as follows:

$$F(x) = \frac{\sum_{i=1}^{N_b} w_i \sum_{j=1}^{M_i} I(x_{ij} < x \text{ and } G_{ij})}{\sum_{i=1}^{N_b} w_i \sum_{j=1}^{M_i} I(G_{ij})} \quad (1)$$

where  $x_i$  is the conductivity value in the  $j^{th}$  sample of bin  $i$ ,  $N_b$  is the total number of bins,  $M_i$  is the number of samples in the  $i^{th}$  bin,  $G_{ij}$  is true if the genus of interest was observed in  $j^{th}$  sample of bin  $i$ , and  $I$  is an indicator function that equals 1 if the indicated conditions are true, and 0 otherwise. The  $XC_{95}$  value is defined as the conductivity value,  $x$  where  $F(x) = 0.95$ . Eq. 1 is an empirical cumulative distribution function, and the output is the proportion of observations of the genus that occur at a given conductivity or lower. However, the individual observations are weighted to account for the uneven distribution of observations across the range of conductivities.

An example of a weighted cumulative distribution function (CDF) is shown in Figure 4 for the mayfly, *Drunella*. The horizontal dashed red line indicates where  $F(x) = 0.95$ , and the conductivity value at the intersection of this line and the CDF is the  $XC_{95}$  value.

This method for calculating the  $XC_{95}$  will generate a value even if the genus is not extirpated. For example, the occurrence of *Nigronia* changes little with increasing conductivity (see Figure 4). Therefore, it is necessary to identify those values that are actual extirpation values. We did this by examining plots of probabilities of occurrence, estimated as the proportion of samples within each bin in which the genus was observed. Examples are shown in Figure 5. The solid line is provided to help illustrate the association, and its position is calculated using a nonparametric smoothing spline fit with 3 degrees of freedom. These curves are not used in the calculation of the  $XC_{95}$ . The conductivity at the red, horizontal, dashed line is the estimated  $XC_{95}$  from the weighted cumulative distribution. The actual  $XC_{95}$  was greater than ( $>$ ) the calculated  $XC_{95}$  if the trend was increasing or flat and the seven highest conductivity bins were not zeros (see Figure 5). For example, the  $XC_{95}$  for *Cheumatopsyche* (an extremely salt tolerant genus) is  $>9,180 \mu\text{S}/\text{cm}$  (see Appendices D-1 and D-2).

### 3.2. TREATMENT OF POTENTIAL CONFOUNDERS

Potentially confounding variables for the relationship of conductivity with the extirpation of stream invertebrates were evaluated in several ways—which are described in Appendix B. Based on the weight of evidence, only low pH was a likely confounder. Because low pH waters are in violation of existing water quality criteria and because the data set was large, we excluded sites with pH <6 before identifying the XC<sub>95</sub> for each genus.

We evaluated the effects of spring benthic invertebrate emergence, temperature, and different conductivities associated with season by partitioning the data set into spring (March–June) and summer (July–October) subsets. However, we found that the SSDs for spring and all year were similar. Therefore, we used the SSD for the combined spring and summer samples, thus avoiding the need to apply judgment to define seasons that vary with longitude and elevation.

To further evaluate the effect of confounders on the HC<sub>05</sub>, XC<sub>95</sub> values for the full year were determined from a data set from which sites were removed as follows:

- pH of <6 (removes acidity and associated dissolved metals as a cause);
- rapid bioassessment protocol (RBP) score <135 (removes marginal habitat conditions as a cause). The RBP score is WV's composited index of qualitative measures of habitat parameters such as bank erosion, stream sinuosity, embeddedness, and cover; and
- fecal coliform >400 colonies/100 mL (removes sources of potential organic enrichment and potential toxicants from sewage treatment plants, failing septic tanks and livestock as causes).

XC<sub>95</sub> values were recalculated with the trimmed data set and compared. That analysis found that the HC<sub>05</sub> (300 µS/cm) was similar to the HC<sub>05</sub> (297 µS/cm) for the data set with only low pH removed so the data set was not partitioned for either RBP score or fecal coliform when calculating the benchmark.

Other potential confounders were evaluated, but they were not partitioned from the data set prior to calculating the XC<sub>95</sub> and HC<sub>05</sub> values. Rather, we evaluated the potential magnitude of confounding by determining the degree of correlation of the confounder with conductivity and with the number of ephemeropteran genera. We also evaluated contingency tables of the occurrence of any Ephemeroptera at a site with respect to high and low levels of conductivity and the potential confounder. Ephemeroptera were selected as an effect endpoint that allowed us to evaluate a greater range of exposures and confounding factors than occurs for individual genera. The confounding analysis focused on Ephemeroptera, because they are among the most

sensitive genera. Other evidence of confounding was included when appropriate data were available.

### 3.3. DEVELOPING THE SPECIES SENSITIVITY DISTRIBUTION

The SSDs are cumulative distribution plots of  $XC_{95}$  values for each genus relative to conductivity (see Figure 6). The cumulative percentile for each genus  $P$  is calculated as  $P = R/(N + 1)$  where  $R$  is the rank of the genus and  $N$  is the number of genera. Some salinity-tolerant genera are not extirpated within the observed range of conductivity. So, like laboratory test endpoints reported as “greater than” values, we retained field data that do not show the field endpoint effect (extirpation) in the database. In this way, they can be included in  $N$  when calculating the proportions responding, because they fall in the upper portion of the SSD. The  $HC_{05}$  was derived by using interpolation to estimate the percentile between the  $XC_{95}$  values bracketing  $P = 0.05$  (i.e., the 5<sup>th</sup> percentile of modeled genera). The benchmark is obtained by rounding the  $HC_{05}$  to two significant figures as directed by Stephen et al. (1985).

Exploratory SSDs were developed using different data sets to evaluate effects of potentially influential factors. The results of these exploratory analyses and other tests are discussed in the treatment of confounding factors (see Appendix B).

### 3.4. CONFIDENCE BOUNDS

The purpose of this analysis is to characterize the statistical uncertainty in the benchmark value by calculating confidence bounds on the  $HC_{05}$  values. Because the  $XC_{95}$  values were estimated from field data and then the  $HC_{05}$  values were derived from those  $XC_{95}$  values, we used a method that generated distributions and confidence bounds in the first step and propagated the statistical uncertainty of the first step through the second step.

Bootstrap estimates of the  $XC_{95}$  were derived for each genus used in the derivation of the benchmark by sampling with replacement from the data set used to derive the benchmark 2,145 times (the number of observations in the data set) (Efron and Tibshirani, 1993). For each bootstrap sample, the  $XC_{95}$  was calculated by the same method applied to the original data (see Section 3.1). That process was repeated 1,000 times to create a distribution of  $XC_{95}$  values for each genus. These distributions were used to calculate a two-tailed 95% confidence interval on the  $XC_{95}$  for each genus. The  $XC_{95}$ s from the original data set, the mean  $XC_{95}$ s of the bootstrap distributions, and the confidence intervals are shown for the most sensitive 35 genera in Figure 7.

Uncertainty in the  $HC_{05}$  value was evaluated by generating an  $HC_{05}$  from each of the 1,000 sets of bootstrapped  $XC_{95}$  estimates. The distribution of 1,000  $HC_{05}$  values was used to generate a two-tailed 95% confidence bounds on these bootstrap-derived values.

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### 3.5. ESTIMATING BACKGROUND

In general, a benchmark should be greater than natural background. The background conductivities of streams were estimated using reference sites from the WABbase. The 75<sup>th</sup> percentile of this distribution in the summer index period (August–October), which is the period of greatest conductivity, is 100  $\mu\text{S}/\text{cm}$  for Ecoregion 69 and 234  $\mu\text{S}/\text{cm}$  for Ecoregion 70. The 75<sup>th</sup> percentile was selected because sites were among the least disturbed based on best professional judgment (U.S. EPA, 2000). We also estimated the background conductivity for the area using only probability samples from the WABbase, which do not rely upon any selection criteria other than representativeness of a stream order. The 25<sup>th</sup> percentile was selected because impaired sites are also included in the random sample (U.S. EPA, 2000). A total of 1,271 probability-based samples were collected from Ecoregions 69 and 70. The background values, based on the 25<sup>th</sup> percentile, were 72  $\mu\text{S}/\text{cm}$  for Ecoregion 69 and 153  $\mu\text{S}/\text{cm}$  for Ecoregion 70. The bases for these methods are explained in Section 5.5.



## 4. RESULTS

### 4.1. EXTIRPATION CONCENTRATIONS

The  $XC_{95}$  values are presented in Appendix C. Values are calculated for all macroinvertebrate genera that were observed at a minimum of 30 sampling sites in the two ecoregions. Distributions of occurrence with respect to conductivity are presented for each genus of macroinvertebrate in Figure D-1 and the CDFs used to derive the  $XC_{95}$  values are presented in Figure D-2.

### 4.2. SPECIES SENSITIVITY DISTRIBUTIONS

SSDs for invertebrates in spring, summer, and the entire sampling year (March through October) are derived from  $XC_{95}$  values of 150 genera (see Figure 6). The SSDs do not reach a horizontal asymptote at 100% of genera because salt-tolerant genera are included in the SSD that are not extirpated within the observed range of conductivity values. The lower third of the SSD is shown in Figure 8 for better viewing of the plots near the 5<sup>th</sup> percentile of genera.

### 4.3. HAZARDOUS CONCENTRATION VALUES AT THE 5TH PERCENTILE

The hazardous concentration values at the 5<sup>th</sup> percentile of the SSDs are summarized in Table 4. The  $HC_{05}$  spring value is lower than the summer value and similar to the full year. The  $HC_{05}$  for year-long  $XC_{95}$  values are similar to spring values because the spring-only genera have low  $XC_{95}$  values (see Figure 6). Other seasonal differences result from exclusion of some taxa due to sample sizes less than 30 in spring or summer or seasonal differences in the ability to sample some genera (see Section 5.2). Rounding the  $HC_{05}$  for all year of 297  $\mu\text{S}/\text{cm}$  to two significant figures yields a benchmark value of 300  $\mu\text{S}/\text{cm}$  (see Figure 8).

### 4.4. UNCERTAINTY ANALYSIS

The following  $HC_{05}$ s resulted from the bootstrap-derived statistics, a lower confidence bound of 225  $\mu\text{S}/\text{cm}$  and an upper confidence bound of 305  $\mu\text{S}/\text{cm}$ . These confidence bounds are asymmetrical with respect to the point estimate of 297  $\mu\text{S}/\text{cm}$ . In general statistical practice, confidence bounds around estimates are not infrequently asymmetric. In the case of bootstrap generated estimates as used here, asymmetry occurs because statistical resampling from the distribution of data generates more realizations that produce values lower than the point estimate than realizations that produce higher values.

Confidence bounds represent the potential range of  $HC_{05}$  values using the SSD approach, given the data and the model. Conceptually, these confidence bounds may be thought of

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1 representing the potential range of HC<sub>05</sub> values that one might obtain by returning to WV and  
2 resampling the streams. The contributors to this uncertainty include measurement variance in  
3 determining conductivity and sampling variance in the locations for monitoring and in collecting  
4 and enumerating organisms. It also includes variance due to differences in stream reaches,  
5 weather, and other random factors.

6 The confidence bounds do not address potential systematic sources of variance such as  
7 differences between geographic areas or between different organizations performing the  
8 sampling using different protocols. The contributions of those sources of uncertainty (in addition  
9 to the sampling uncertainty) can best be evaluated by comparing results of independent studies.  
10 One estimate of that larger uncertainty is provided by comparing the all-year HC<sub>05</sub> values  
11 derived from West Virginia and Kentucky data. Even though the data were obtained in different  
12 areas by different agencies using different protocols, the values differ by only 7% (see  
13 Appendix E for details). In addition, the 95% confidence bounds on the HC<sub>05</sub> values for the two  
14 states overlap, suggesting that the sampling variance (i.e., the uncertainty captured by the  
15 confidence intervals) may be the largest component of total uncertainty. While this result is from  
16 only one comparison of two states, it does provide a reassuring validation of the WV results.

## 5. CONSIDERATIONS

Because of the complexity of field observations, decisions must be made when deriving field-based benchmark values that are not required when using laboratory data. In the case of conductivity, additional decisions must be made to address a pollutant that is a mixture and a naturally occurring constituent of water.

### 5.1. SELECTION OF INVERTEBRATE GENERA

Selection of genera to model can affect the results. Using the data set of all taxa includes taxa that may occur due to a competitive advantage in polluted water. Some taxa, such as *Corbicula*, are not native to streams in North America. Using only genera found at sites with minimal disturbance as defined by reference sites somewhat alleviates this problem. The reference site genera are often linked to state narrative water quality standards; thus, they represent the aquatic life use that state water quality criteria should be designed to protect. Furthermore, the importance of losing species that inhabit minimally disturbed sites may be clearer to decision makers and stakeholders. In this particular case, using all genera including invasive species would increase HC<sub>05</sub> by only 2% in the full year data set.

Genera are also selected for statistical reasons. We restricted genera used in analysis to those recorded at a minimum of 30 sampling sites to reduce the chance that an apparent extirpation is due to sampling variance and to increase the likelihood that the models and exploratory analyses for potential confounding are reasonably strong.

### 5.2. SEASONALITY, LIFE HISTORY, AND SAMPLING METHODS

The seasonality of life history events such as emergence of aquatic insects can affect the probability of detecting a species, because eggs and early instars are not captured by the sampling methods used. As a result, annual insects that emerge in the spring are present but unlikely to be detected in the summer, when conductivities increase in some streams.

Some invertebrate genera are observed only in the spring probably due to the size of the early life stages or diapausing eggs in summer months. Because many of these same genera may be among the most sensitive genera, they could have a strong influence on the HC<sub>05</sub>. Therefore, we evaluated the summertime conductivities of the streams in which these genera were found in springtime. The conductivities of these streams were often stable throughout the year (see Figure 9), but in some streams that supported sensitive genera in spring, conductivities increased in the summer. This suggests that some genera might withstand higher conductivities that coincide with certain parts of a genus's lifecycle; however, these genera clearly do not tolerate

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1 those conductivities in the spring. Lower effects levels were not due to insufficient test range of  
2 conductivities because exposures as high as 5,200  $\mu\text{S}/\text{cm}$  occurred in the spring samples.  
3 Furthermore, when we partitioned the data into spring and summer periods, the XC values are  
4 lower in the spring than in the summer (see Figures 6 and 8).

5 The effects of seasonality and life history were evaluated by comparing occurrences of  
6 individual invertebrate genera and  $\text{XC}_{95}$  and  $\text{HC}_{05}$  values partitioned for season (see Figures 6  
7 and 8). The data set was partitioned into spring and summer based on seasonal patterns of  
8 conductivity at WVDEP reference sites (see Figure 2). The spring season is March through  
9 June. The summer season is July through October. The exposure is characterized by water  
10 quality parameters measured on the same date that a taxon is observed in the stream. Both high  
11 and low conductivity streams are represented in both spring and summer samples. However, the  
12 conductivity in certain streams may be three times greater in the summer than the spring.

13 We cannot be sure whether the greatest exposures in summer are tolerated by the  
14 spring-emergent genera. However, streams with conductivity  $<300 \mu\text{S}/\text{cm}$  in summer are also  
15 below the benchmark in spring 98% of the time (see Figure 10). For simplicity, we recommend  
16 the year-round value (see Section 6), but seasonal variation should be considered when planning  
17 monitoring of conductivity.

### 18 19 **5.3. INCLUSION OF REFERENCE SITES**

20 If high quality (i.e., reference) sites are not included in the data set, effects on sensitive  
21 species will not be incorporated into the benchmark. That is, the lower end of the SSD will be  
22 missing. For example, in a region where all watersheds include tilled agricultural land uses, all  
23 sites are affected by sediment, so a legitimate SSD for sediment should not be derived by this  
24 method in that region. In this case, WVDEP's reference sites were included as well as many  
25 probability sites with  $>90\%$  forest cover, which are believed to be representative of good- to  
26 high-quality systems.

### 27 28 **5.4. DEFINING THE REGION OF APPLICABILITY**

29 If the method described here is applied to a large region, the increased range of  
30 environmental conditions and a greater diversity of anthropogenic disturbances may obscure the  
31 causal relationship. However, if the region is too small, the available data set may be inadequate,  
32 and the resulting benchmark value will have a small range of applicability. In this case, we  
33 chose two adjoining regions that have abundant data,  $>90\%$  of genera in common, and a  
34 common dominant source of the stressor of concern.

## 5.5. BACKGROUND

For naturally occurring stressors, it would *not*, in general, be appropriate to derive a benchmark value that is within the background range. In this case, background conductivities for Ecoregions 69 and 70 are 100 and 234  $\mu\text{S}/\text{cm}$ , respectively, using 75<sup>th</sup> percentiles of reference sites in West Virginia. Reference sites are sites that are judged to be among the best within a category, but they are not necessarily pristine or representative of natural background. Some reference sites have unrecognized disturbances or have recognized disturbances that are less than most others in their category. Some have extreme values of a stressor because of measurement error or unusual conditions at the time the sample was taken. For those reasons, when estimating background concentrations, it is conventional to use only the best 75% of reference values. The cutoff percentile is based on precedent and on the collective experience of EPA field ecologists (U.S. EPA, 2000).

The background values based on the 25<sup>th</sup> percentile range between 72  $\mu\text{S}/\text{cm}$  for Ecoregion 69 ( $n = 617$ ) and 153  $\mu\text{S}/\text{cm}$  ( $n = 654$ ) for Ecoregion 70 for probability samples in West Virginia. Samples from a probability design include all types of waters including impaired sites. In some regions there are no pristine streams. To characterize the best streams, the 25<sup>th</sup> percentile is commonly used by EPA field ecologists (U.S. EPA, 2000). None of these values exceed the  $\text{HC}_{05}$  values in Table 4.

## 5.6. INCLUSION OF OTHER TAXA

Fish were not included because their occurrence is affected by stream size making it difficult to determine  $\text{XC}_{95}$  values. Some of the affected streams naturally have no fish. In addition, the WABbase data set used to derive the benchmark does not contain data for fish. Other data sets that do contain fish are not as large and do not contain as great a range of conductivity values. A separate SSD might be developed for fish, once these technical issues are resolved. Data for plants and amphibians are not available. Additional findings regarding mussels could change this analysis if they are found to be more sensitive to conductivity than the invertebrates used here. Mussels were not represented because genera did not occur in a minimum of 30 samples. Additional analyses may be necessary to ensure protection of federally or state listed rare, threatened, or endangered species of fish, amphibians, and mussels.

## 5.7. TREATMENT OF RARE SPECIES

Species listed by West Virginia Department of Natural Resources (WVDNR, 2007) as threatened were among the genera observed. Because taxa were identified to genus, we are not certain if the species are included. Therefore, we recommend that the invertebrate taxa,

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1 Alloperla, Pteronarcys, Cordulegaster, Ephemera, and Sweltsa, be identified to species in  
2 subsequent monitoring to evaluate the risk to these threatened taxa. Furthermore, freshwater  
3 mussels were not well represented in the samples perhaps due to the sampling methods. Stephan  
4 et al. (1985) recommend lowering the concentration below the 5<sup>th</sup> percentile when necessary to  
5 protect threatened, endangered, or otherwise important species.

## 6 7 **5.8. SELECTION OF THE EFFECTS ENDPOINT**

8 We have used the extirpation concentration as the effects endpoint, because it is easy to  
9 understand that an adverse effect has occurred when a genus is lost from an ecosystem.  
10 However, for the same reason, it may not be considered protective. An alternative is to use a  
11 depletion concentration (DC<sub>x</sub>) based on a percent reduction in abundance or capture probability.  
12 Another option is to use only those taxa sensitive to the stressor of concern, thus developing an  
13 SSD for the most relevant taxa. DC values or other more sensitive endpoints may be considered  
14 when managing exceptional resources.

15 In this study, an invertebrate genus may represent several species, and this approach  
16 identifies the pollutant level that extirpates all species within that genus (i.e., it is the level at  
17 which the least sensitive among them is rarely observed). In a review of extrapolation methods,  
18 Suter (2007) indicated that although species within a genus respond similarly to toxicants,  
19 different species within a genus may have evolved to partition niches afforded by naturally  
20 occurring causal agents such as conductivity. Hence, an apparently salt tolerant genus may  
21 contain both sensitive species and tolerant species. A potential solution would be to use distinct  
22 species. However, this may not be practical because some taxa are very difficult to identify  
23 except as late instars. We chose to follow Stephen et al. (1985) by using genera until such time  
24 that the advantages and disadvantages of using species can be more fully studied.

## 25 26 **5.9. USE OF MODELED OR EMPIRICAL DISTRIBUTIONS**

27 When deriving XC and HC values, one might use a percentile of an empirical distribution  
28 or fit a function to the data and calculate the value from the resulting model. Models use all of  
29 the data and, therefore, are resistant to biases associated with any peculiar data at the percentiles  
30 of interest or to uneven distributions of data. However, there is no a priori reason to believe that  
31 these distributions have a prescribed mathematical form, and fitted models may fit the data  
32 poorly at the percentiles of interest. The use of a nonparametric regression method to alleviate  
33 the problem of assuming a particular functional form can result in biologically unlikely forms,  
34 may reduce the potential generality of the model, and is not readily understood. The use of  
35 empirical distribution functions without fitted models eliminates the problems of model selection

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and makes the method easier to understand and implement. With respect to SSDs, this issue is unresolved, and assessors are encouraged to consider the properties of their distributions when deciding whether to fit or not (Newman et al., 2002; Suter et al., 2002). In this case, data are abundant, and either the empirical or modeled methods could work well. In the interest of conceptual and operational simplicity, we identify the  $XC_{95}$  as the conductivity value at which the empirical cumulative probability is 0.95. Similarly, the  $HC_{05}$  is determined by interpolation of points on the empirical distributions of  $XC_{95}$  values as described in Stephan et al. (1985).

#### 5.10. TREATMENT OF CAUSATION

Causation should not be an issue in laboratory toxicity tests, but, even with rigorous treatment of confounders, skeptics will question whether observed field relationships are truly causal (Kriebel, 2009). Like many epidemiologists, we believe that statistical analysis of relationships should be supplemented by the consideration of qualitative criteria for causation. In this case, we used evidence of causal characteristics derived from Hill's considerations (Cormier et al., 2010) to evaluate the causal relationship of conductivity and extirpation of organisms (see Appendix A).

#### 5.11. TREATMENT OF MIXTURES

In natural waters, salinity is a result of mixtures of ions. We use conductivity as a measure of the mixture. However, waters with different mixtures of salts but the same conductivity may have different toxicities. In this case, the benchmark value was calculated for a relatively uniform mixture of ions in those streams that exhibit elevated conductivity in the Appalachian Region associated with salts dominated by  $SO_4^{2-}$  and  $HCO_3^-$  anions at circum-neutral to mildly alkaline pH. Recent increases in drilling for natural gas may change the toxicity of salinity in this region, and monitoring should be designed to evaluate differences. The relative contributions of individual salts from large scale surface coal mining were described by Pond et al. (2008). Whereas  $Ca^{2+}$ ,  $Mg^{2+}$ ,  $SO_4^{2-}$ , and  $HCO_3^-$  are the four most common ions to drain from surface coal mines, ions of  $Na^+$  and  $Cl^-$  are the two most common in seawater and brines from Marcellus Shale drilling operations (Bryant et al., 2002). Because the few sites with very elevated  $Cl^-$  were found to be outliers in the distributions of occurrence, they were deleted from the data set used to derive the  $XC_{95}$  values. Hence, the use of the benchmark value in other regions or in waters that are contaminated by other sources such as road salt or irrigation return waters may not be appropriate. However, for the circum-neutral to alkaline drainage from surface mines and valley fills, these four primary ions are highly correlated with conductivity (see Figures 11a–e).

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## 6. AQUATIC LIFE BENCHMARK

The aquatic life benchmark of 300  $\mu\text{S}/\text{cm}$  was developed for year-round application. This level is intended to prevent the extirpation of 95% of invertebrate genera in this region. The estimated two-tailed 95% lower confidence bound of the  $\text{HC}_{05}$  point estimate is 225  $\mu\text{S}/\text{cm}$  and the upper bound is 305  $\mu\text{S}/\text{cm}$ .

The aquatic life benchmark has been validated by an independent data set. Application of the same methodology to data from the State of Kentucky gave a very similar result, 319  $\mu\text{S}/\text{cm}$  with a lower confidence bound of 180  $\mu\text{S}/\text{cm}$  and an upper bound of 439  $\mu\text{S}/\text{cm}$  (see Appendix E).

The method used to develop the benchmark is an adaptation of the standard method for deriving water quality criteria for aquatic life (Stephan et al., 1985), so it is supported by precedent. Because the organisms are exposed throughout their life cycle, this is a chronic value.

The aquatic life benchmark for conductivity is provided as scientific advice for reducing the increasing loss of aquatic life in the Appalachian Region associated with a mixture of salts dominated by salts of  $\text{SO}_4^{2-}$  and  $\text{HCO}_3^-$  anions at circum-neutral pH. The aquatic life benchmark for conductivity is applicable to parts of West Virginia, which provided the data for its derivation, and Kentucky, which gave essentially the same result. It may be applicable to Ohio, Tennessee, Pennsylvania, and Maryland in Ecoregions 68, 69, and 70. (Region 68 [Southwestern Appalachia] does not occur in WV and is not included in the derivation of the benchmark value, but it is included in the validation data set from Kentucky [see Appendix E]). The aquatic life benchmark may also be appropriate for other nearby regions. However, this level may not apply when the relative concentrations of dissolved ions are different (see Table 1 for the ranges of concentrations in the data set used to derive the benchmark value).



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**Table 1. Summary statistics of the measured water quality parameters**

	<b>Units</b>	<b>Min</b>	<b>25<sup>th</sup> percentile</b>	<b>Median</b>	<b>75<sup>th</sup> percentile</b>	<b>Max</b>	<b>Mean</b>	<b>Valid N</b>
Conductivity	µS/cm	15.4	153	269.5	576	11,646	490.90	2,145
Hardness	mg/L	0.51	52.04	94.97	196.44	1,491.79	181.73	1,087
Alkalinity	mg/L	0.2	32.05	69.6	120	560	86.57	1,366
SO <sub>4</sub>	mg/L	1	17.5	40	170.8	6,000	179.4	1,365
Ca, total	mg/L	0.002	14	26.2	51.1	430	48.89	1,091
Mg, total	mg/L	0.05	3.94	6.6	14.91	204	14.39	1,089
Chloride	mg/L	1	3	5.53	12.03	1,153	17.93	1,055
TSS	mg/L	1	3	4	6	190	6.5	1,380
Fe, total	mg/L	0.005	0.14	0.27	0.51	110	0.75	1,369
NO <sub>2</sub> -NO <sub>3</sub>	mg/L	0.01	0.1	0.21	0.38	30	0.47	1,113
Al, total	mg/L	0.01	0.09	0.12	0.24	12	0.27	1,372
Al, dissolved	mg/L	0.011	0.02	0.05	0.06	0.93	0.055	1,225
Fe, dissolved	mg/L	0.001	0.02	0.05	0.061	31.8	0.147	1,196
Mn, total	mg/L	0.003	0.02	0.042	0.105	7.25	0.145	1,367
Mn, dissolved	mg/L	0.01	0.03	0.07	0.22	1.06	0.16	19
Total phosphate	mg/L	0.01	0.02	0.02	0.03	2.36	0.039	1,116
Se, dissolved	mg/L	0.001	0.001	0.001	0.001	1.26	0.006	290

**Table 1. Summary statistics of the measured water quality parameters (continued)**

	<b>Units</b>	<b>Min</b>	<b>25<sup>th</sup> percentile</b>	<b>Median</b>	<b>75<sup>th</sup> percentile</b>	<b>Max</b>	<b>Mean</b>	<b>Valid N</b>
Se, total	mg/L	0.0003	0.001	0.001	0.005	1.26	0.006	472
Fecal coliform	counts/100 mL	0.19	40	175	600	250,000	1,515	1,998
DO	mg/L	1.0	8.2	9.2	10.2	18.4	9.2	2,118
pH	standard units	6.02	7.29	7.63	7.97	10.48	7.6	2,145
Catchment area	km <sup>2</sup>	0.08	3.71	10.47	31.64	153.82	24.86	2,141

TSS = Total suspended solids

Note: K<sup>+</sup> and Na<sup>+</sup> not measured

**Table 2. Number of samples with reported genera and conductivity meeting our acceptance criteria for calculating the benchmark value.** Number of samples is presented for each month, ecoregion, and database

Region	Month								Total
	3	4	5	6	7	8	9	10	
69	1	63	188	103	79	267	232	58	987
70	4	186	232	179	194	237	118	8	1,158
Total	5	249	420	282	273	504	350	62	2,145

**Table 3. Genera excluded from 95<sup>th</sup> percentile extirpation concentration calculation because they never occurred at reference sites**

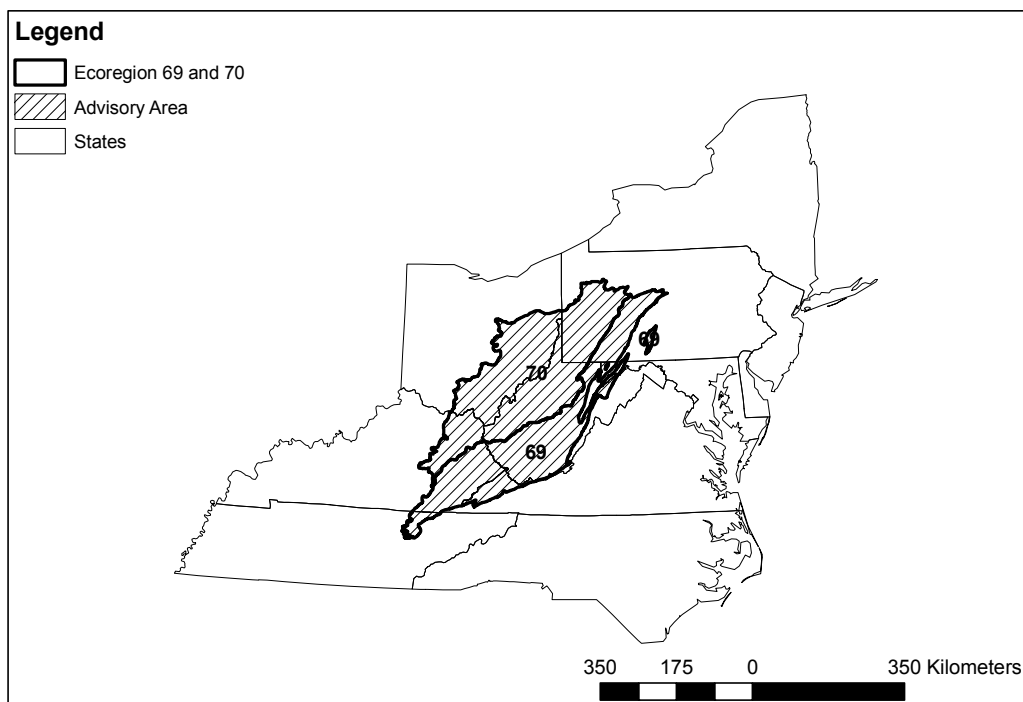
Argia	Baetisca	Calopteryx	Chironomus	Corbicula
Dineutus	Ferrissia	Fossaria	Palpomyia	Paratendipes
Nanocladius	Prostoma	Sphaerium	Stenochironomus	Stictochironomus
Tokunagaia	Tribelos	Tricorythodes		

**Table 4. Hazardous concentration at the 5<sup>th</sup> percentile for invertebrates in Ecoregions 69 and 70**

Season	HC <sub>05</sub>
All year	297 µS/cm
Spring	322 µS/cm
Summer	479 µS/cm

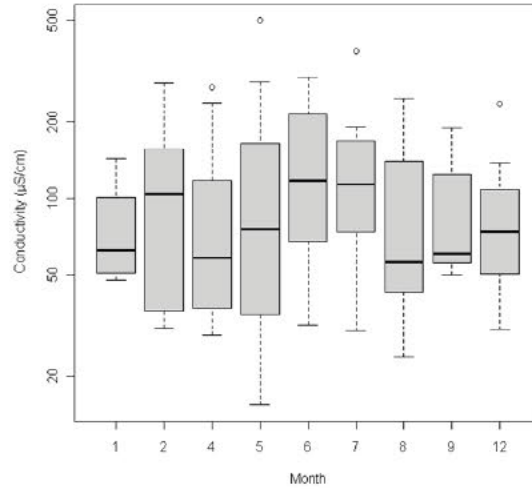
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## Omernik Level III Ecoregions 69 and 70

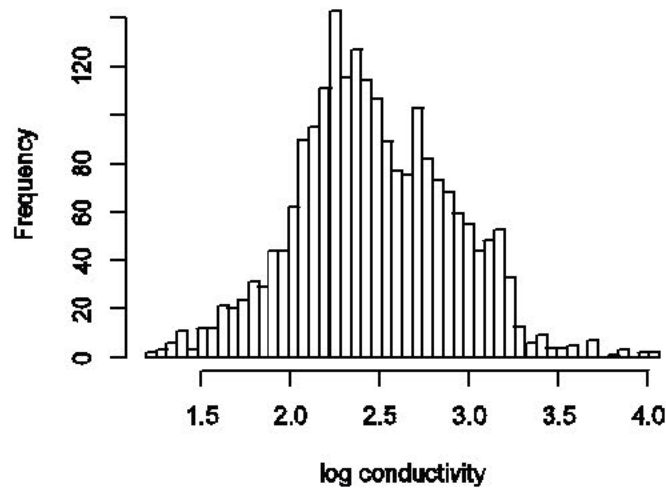


**Figure 1. Data are from Tier III Ecoregions 69 and 70 spanning the states of Ohio, Pennsylvania, Kentucky, Tennessee, West Virginia, and Maryland.**

Data source: State outlines from U.S. EPA Base Map Shapefile, Omernik Level III Ecoregions from National Atlas (National Atlas.gov) Projection NAD1983UTM17N.

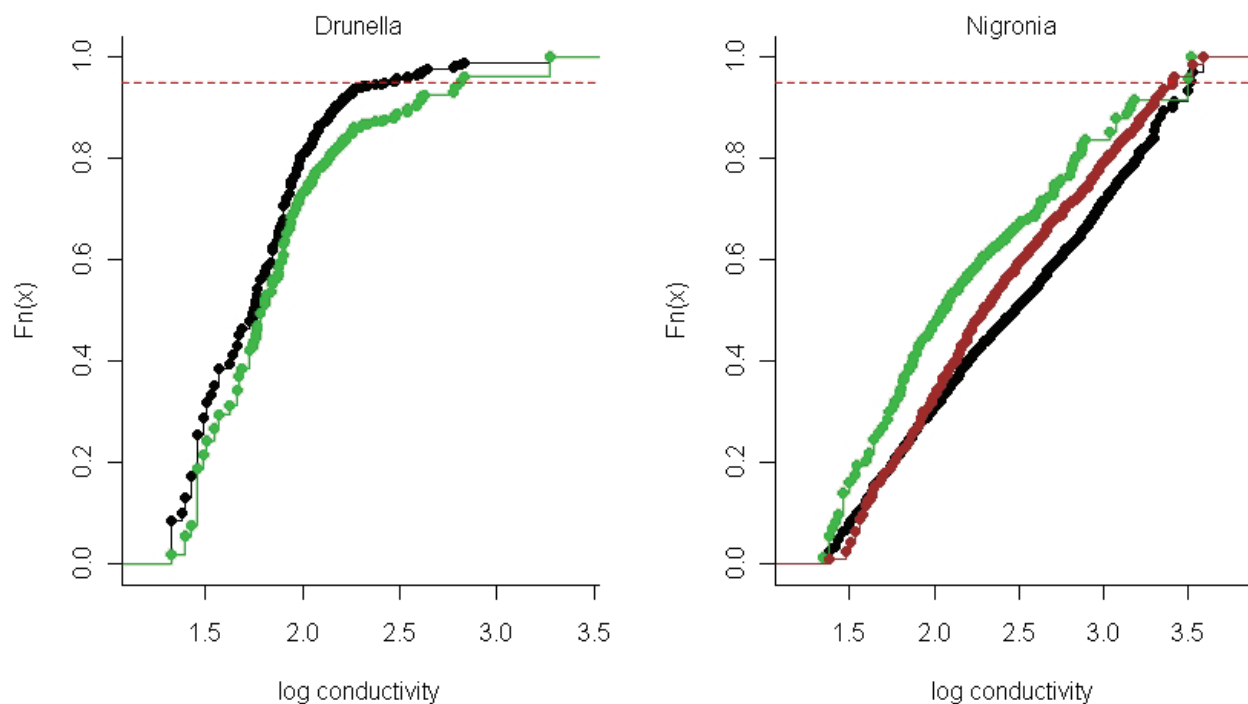


**Figure 2. Box plot showing seasonal variation of conductivity ( $\mu\text{S}/\text{cm}$ ) in the reference streams of Ecoregions 69 and 70 in West Virginia from 1999 to 2006.** A total of 97 samples from 70 reference stations were used for this analysis. The 75<sup>th</sup> percentiles were below 200  $\mu\text{S}/\text{cm}$  in most years.

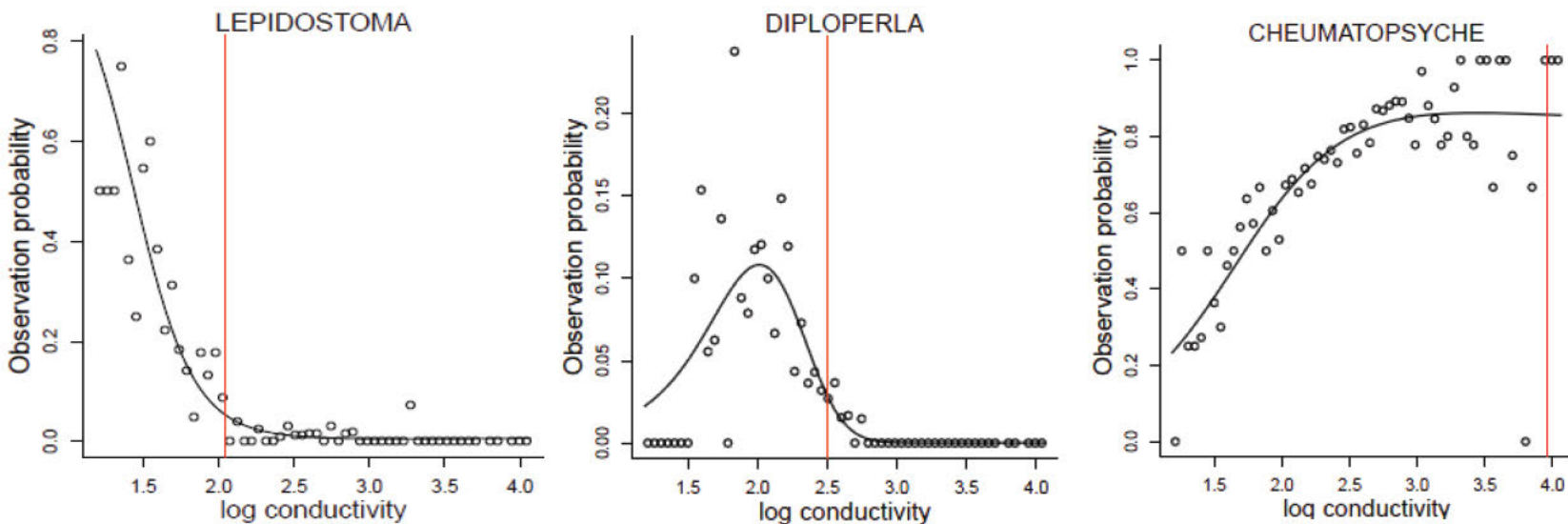


**Figure 3. Histogram of the frequencies of observed conductivity values in samples from Ecoregions 69 and 70 from March to October.** More of the sampled sites were in the midrange than in the extremes.

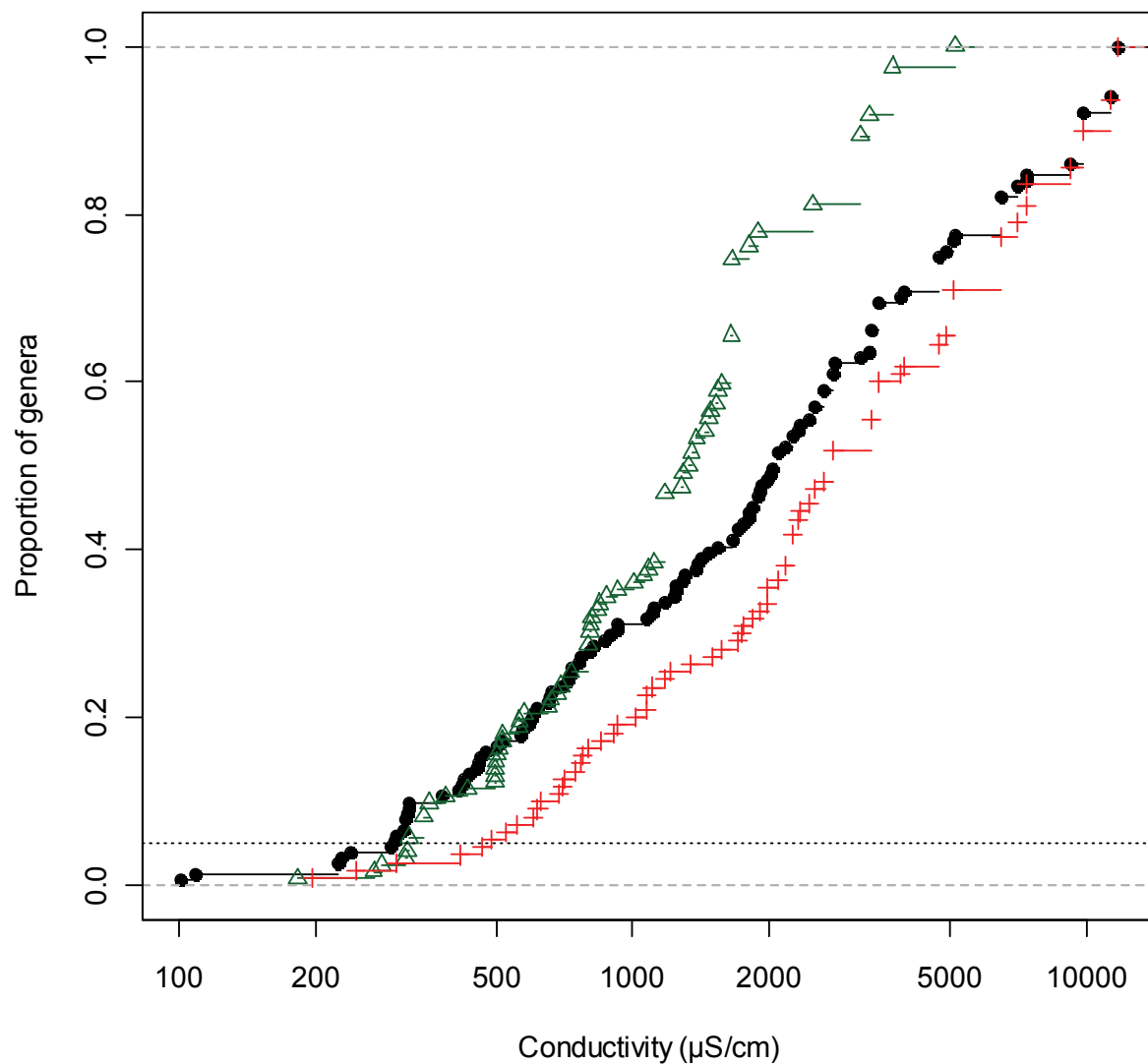




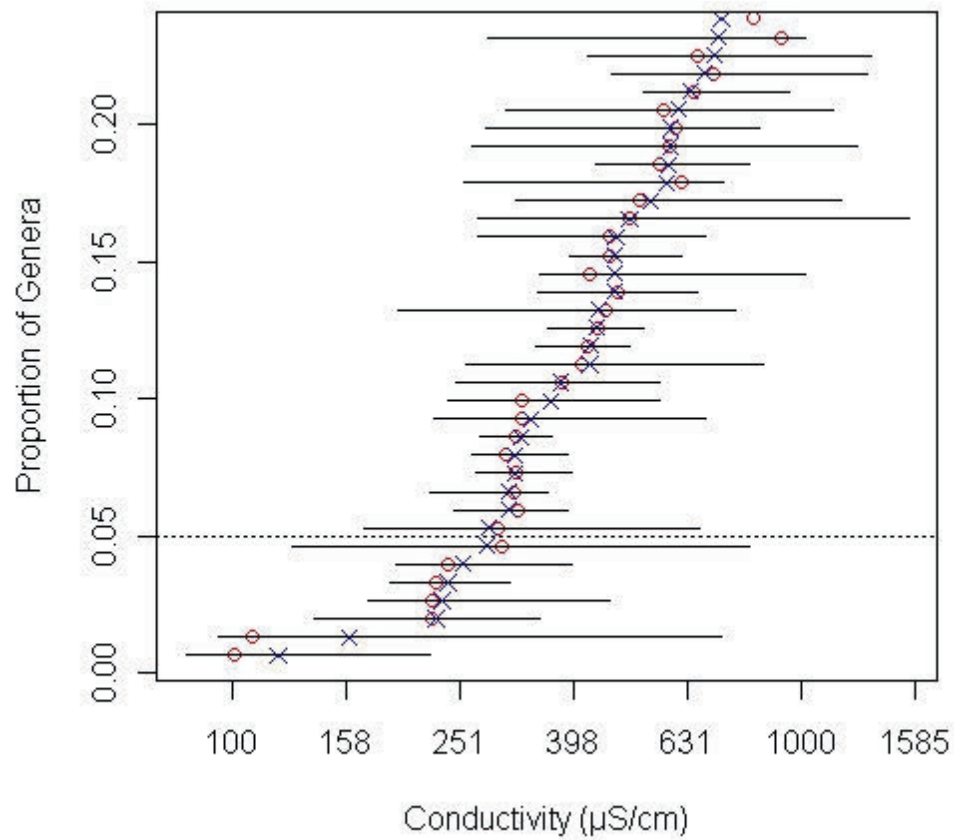
**Figure 4. Example of a weighted CDF and the associated 95<sup>th</sup> percentile extirpation concentration value.** Each point shows the weighted proportion of samples with *Drunella* or *Nigronia* present at ( $F_n(x)$ ) the conductivity less than the indicated conductivity value ( $\mu\text{S}/\text{cm}$ ). The  $\text{XC}_{95}$  is the conductivity at the 95<sup>th</sup> percentile of the cumulative distribution function (CDF) (horizontal dashed line). The CDF was calculated from observations from March through October (all year; black connected points) from March through June (spring; green connected points), and from July through October (summer; red connected points). As there were fewer than 30 observations of *Drunella* between July and October, no CDF was developed for the summer index period. In a CDF, genera that are affected by increasing conductivity (e.g., *Drunella*) show a steep slope and asymptote well below the measured range of exposures; whereas, genera unaffected by increasing conductivity (e.g., *Nigronia*) have a steady increase over the entire range of measured exposure and do not reach a perceptible asymptote.



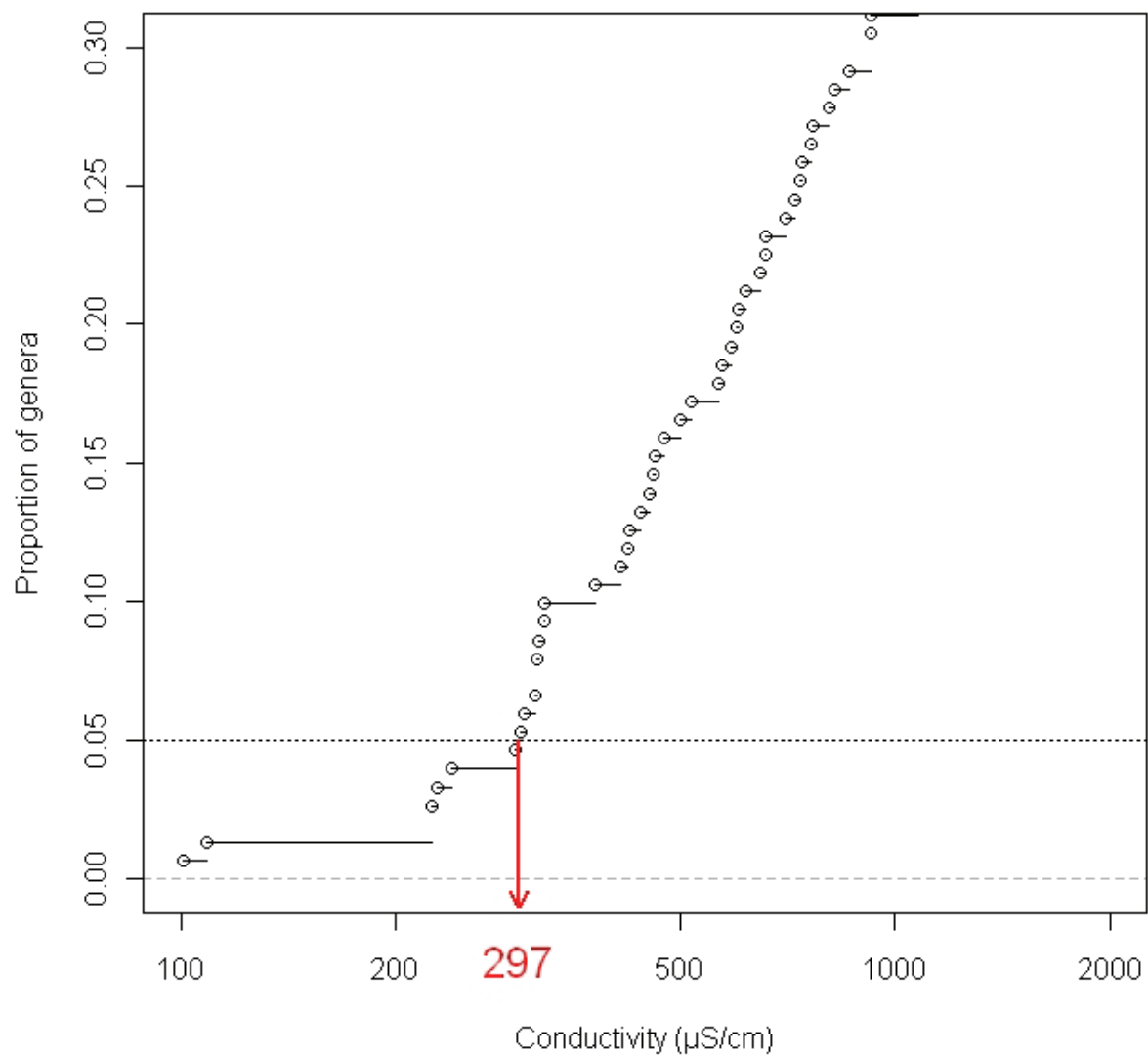
**Figure 5. Three typical distributions of observation probabilities (March through October).** Open circles are the probabilities of observing the genus within a range of conductivities. Circles at zero probability indicate no individuals at any sites were found at these conductivities. The line fitted to the probabilities is for visualization. The vertical red line indicates the  $XC_{95}$ . Note that different genera respond differently to increasing salinity. *Lepidostoma* declines, *Diploperla* has an optimum, and *Cheumatopsyche* increases. The  $XC_{95}$  for genera like *Cheumatopsyche* are reported as “greater than” because extirpation did not occur in the measured range.



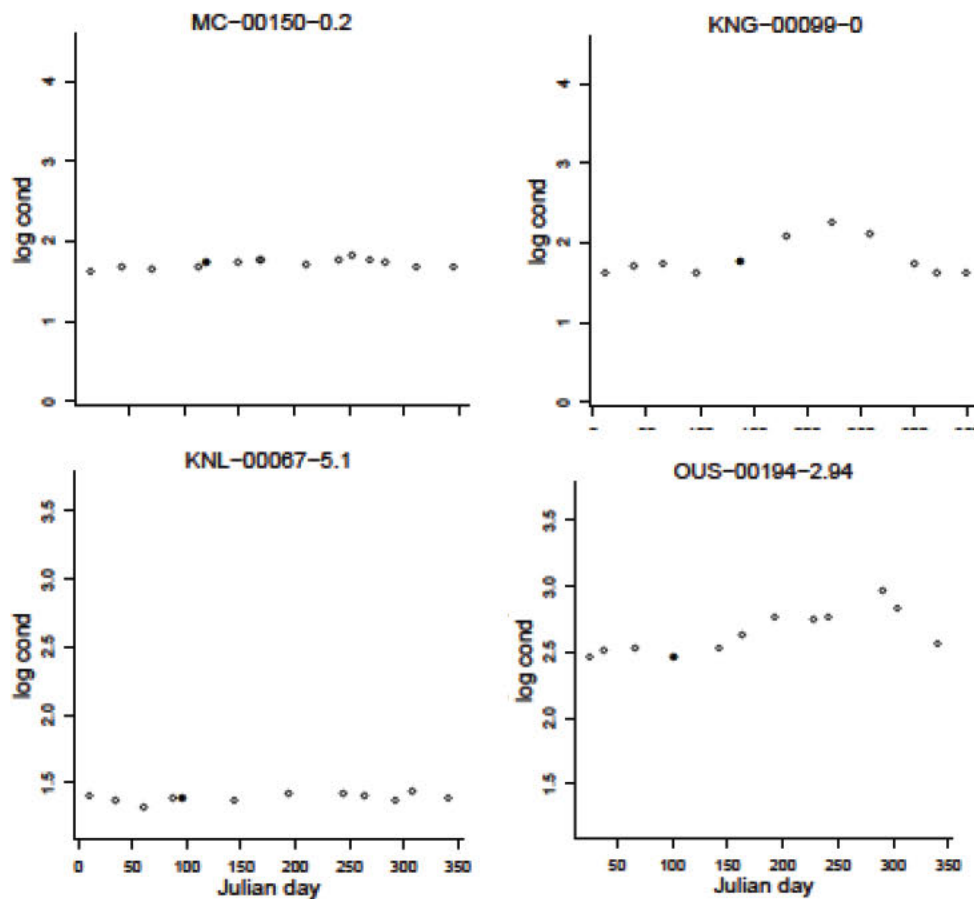
**Figure 6. The species sensitivity distribution for all year (March through October [black circles], March through June [green triangles], and July through October [red +]).** More than 100 genera are included. The  $HC_{05}$  is the conductivity at the intercept of the CDF with the horizontal line at the 5<sup>th</sup> percentile.



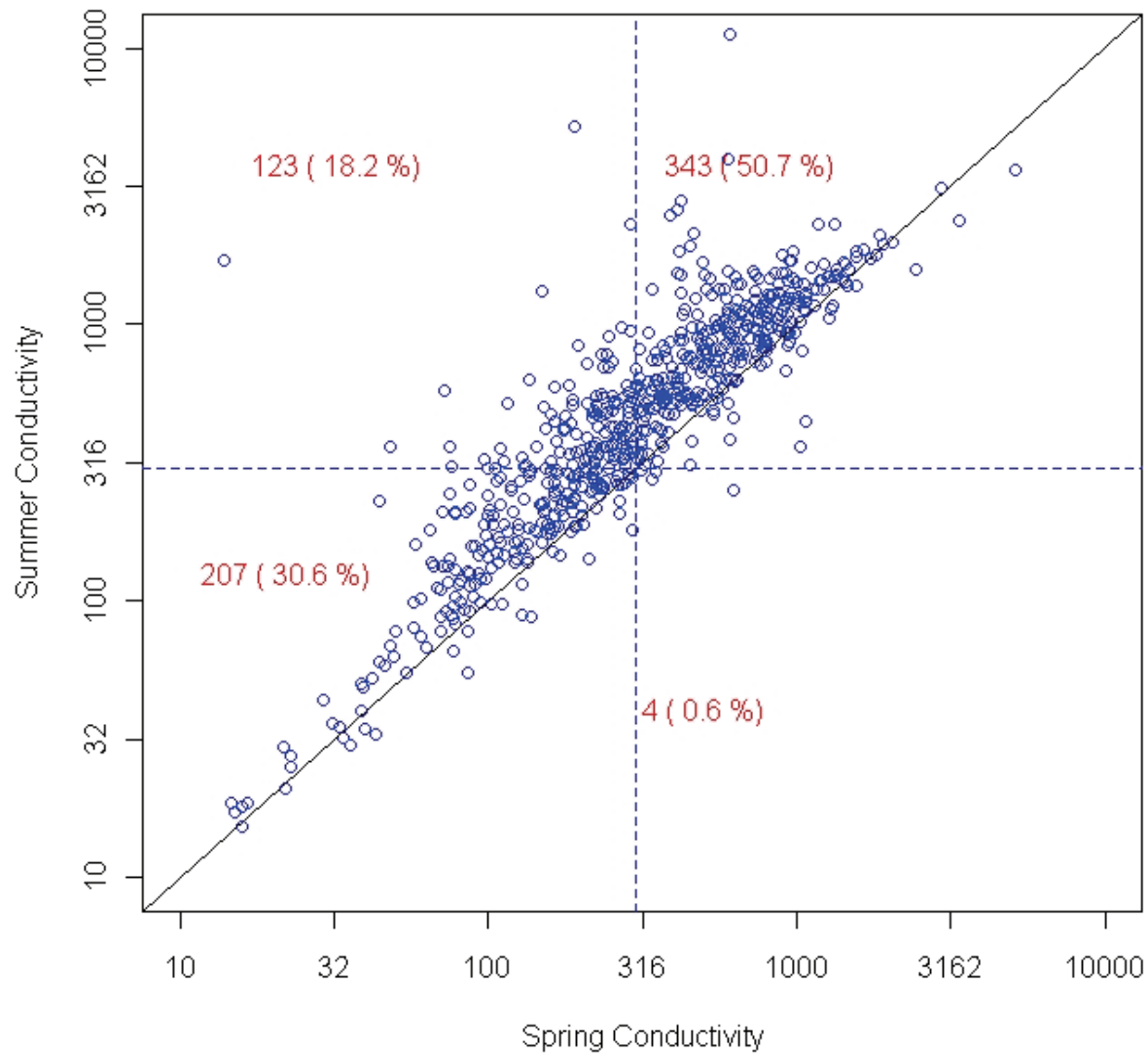
**Figure 7. The cumulative distribution of  $XC_{95}$  values for the 35 most sensitive genera (red circles) and the bootstrap-derived means (blue x symbol) and two-tailed 95% confidence intervals (whiskers). The 5<sup>th</sup> percentile is shown by the dashed line.**



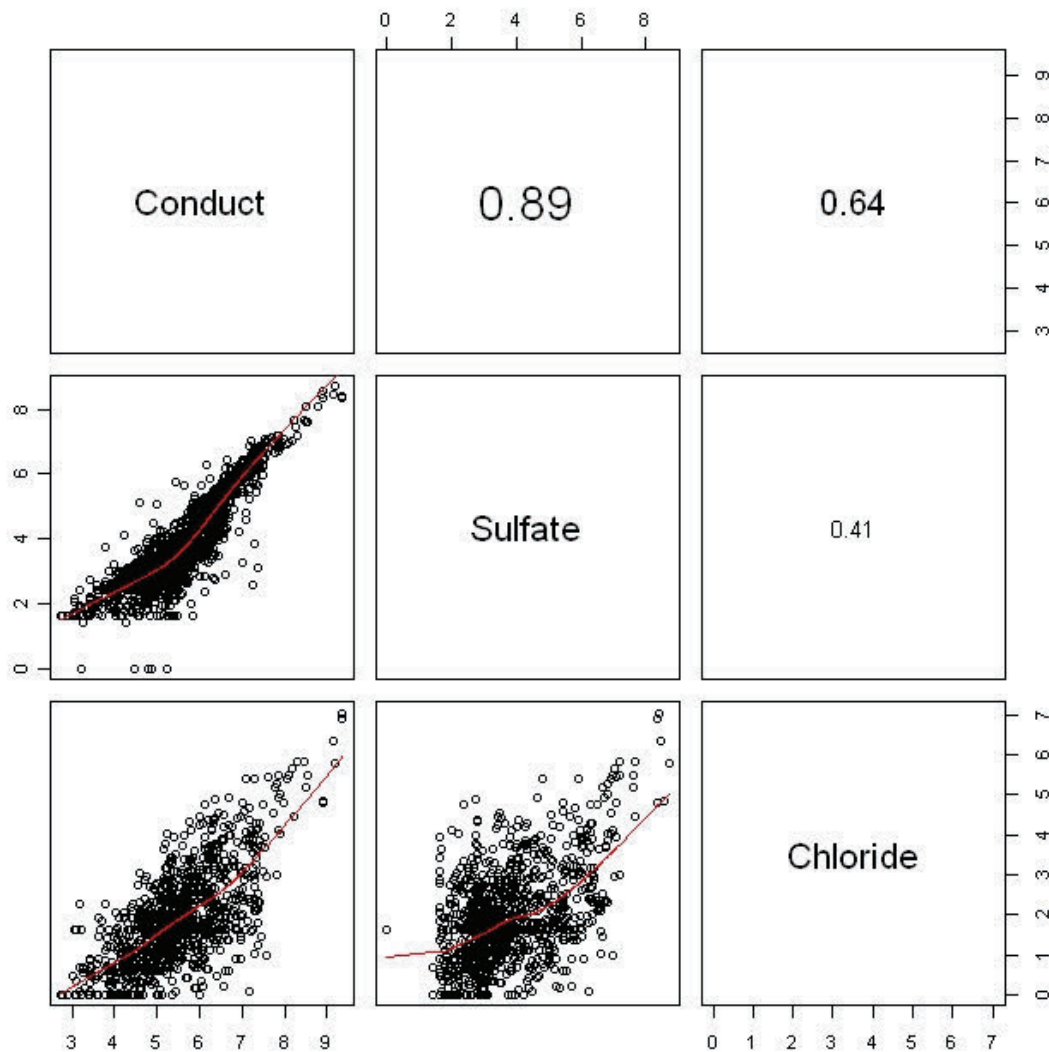
**Figure 8. Species sensitivity distribution for all year.** The dotted horizontal line is the 5<sup>th</sup> percentile. The vertical arrow indicates the HC<sub>05</sub> of 297 µS/cm. Only the lower 50 genera are shown to better discriminate the points in the left side of the distribution.



**Figure 9. Examples of a monthly year-long stream conductivity record in a stream.** Filled circles: events when macroinvertebrates were sampled concurrently with conductivity; open circles: physical-chemical sampling only. Some streams had a steady level of conductivity (plots on left); others increased in summer month (plots on right).

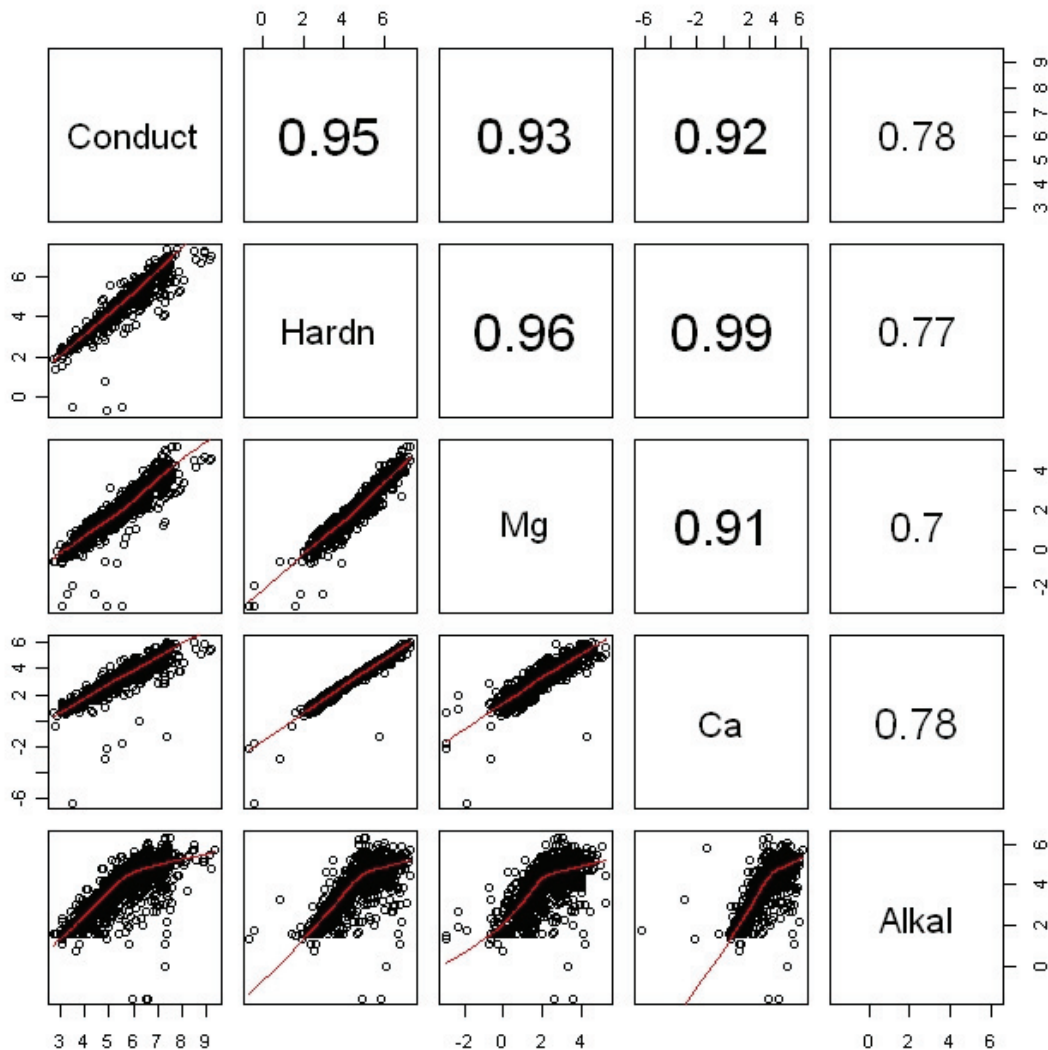


**Figure 10. Correlation of conductivity values sampled from the same site in spring and summer.** When conductivity is <300  $\mu\text{S}/\text{cm}$  (broken lines) in March thru June, the conductivity is <300  $\mu\text{S}/\text{cm}$  in the same stream 63% of the time July through October. When the conductivity is <300  $\mu\text{S}/\text{cm}$  in July through October, the conductivity in the same stream March through June is <300  $\mu\text{S}/\text{cm}$  98% of the time.

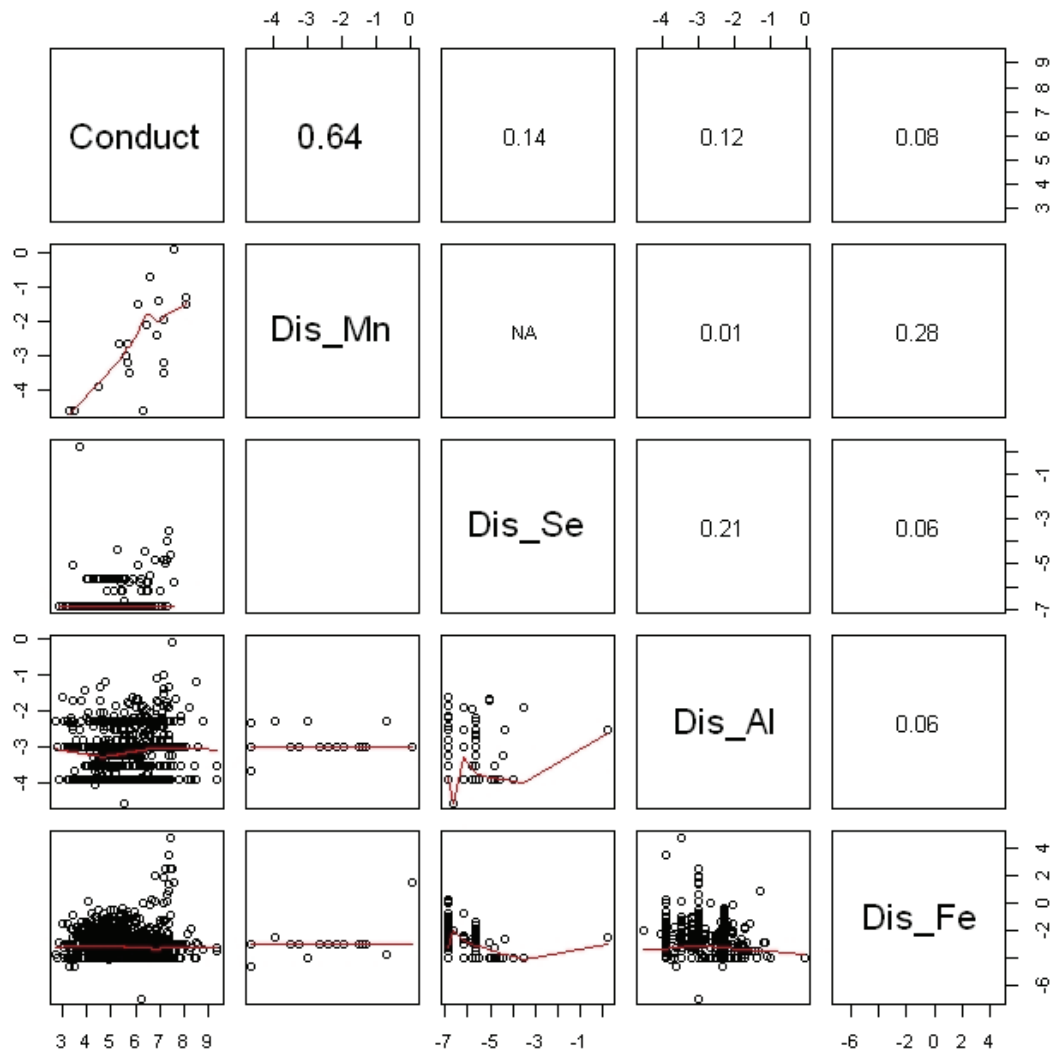


**Figure 11a. Anions.** Matrix of scatter plots and absolute Spearman correlation coefficients between conductivity ( $\mu\text{S}/\text{cm}$ ), sulfate ( $\text{mg}/\text{L}$ ), and chloride concentrations ( $\text{mg}/\text{L}$ ) in streams of Ecoregions 69 and 70 in West Virginia. All variables are logarithm transformed. The smooth lines are the locally weighted scatter plot smoothing (LOWESS) lines (span = 2/3).

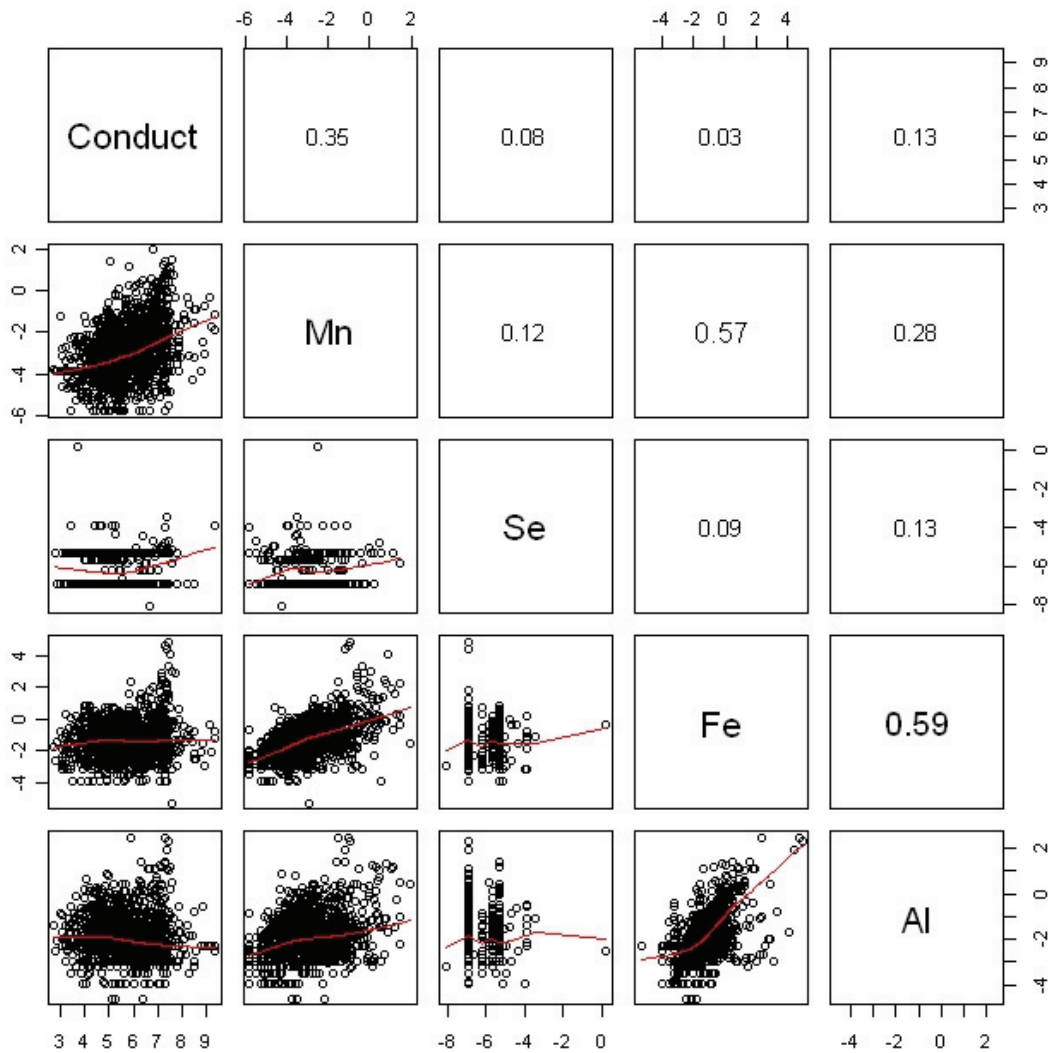




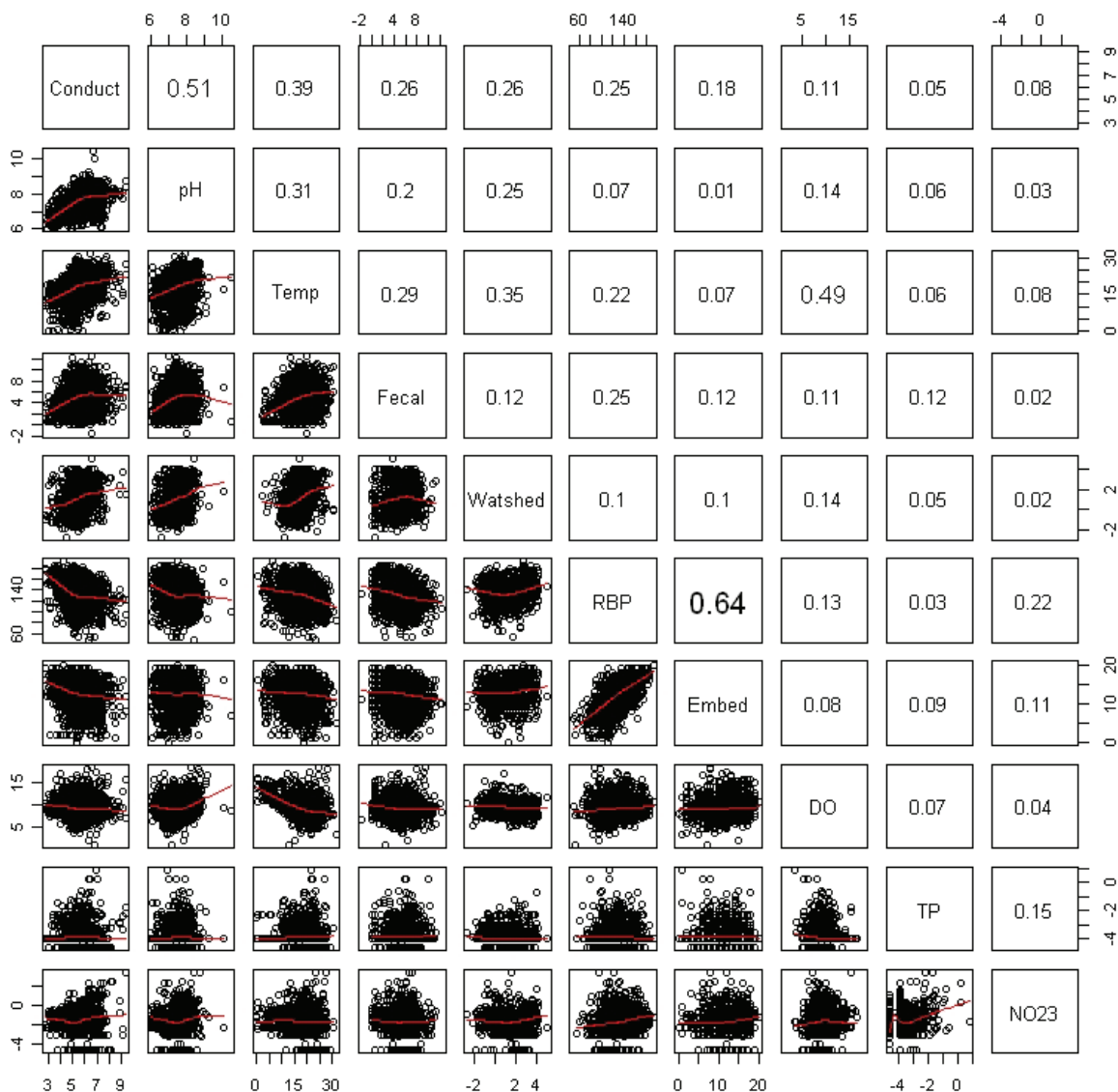
**Figure 11b. Cations.** Matrix of scatter plots and absolute Spearman correlation coefficients between conductivity ( $\mu\text{S}/\text{cm}$ ), hardness ( $\text{mg}/\text{L}$ ), Mg ( $\text{mg}/\text{L}$ ), Ca ( $\text{mg}/\text{L}$ ), and alkalinity ( $\text{mg}/\text{L}$ ) in the streams of Ecoregions 69 and 70 in West Virginia. All variables are logarithm transformed. The smooth lines are the locally weighted scatter plot smoothing (LOWESS) lines (span = 2/3).



**Figure 11c. Dissolved metals.** Matrix of scatter plots and absolute Spearman correlation coefficients among conductivity ( $\mu\text{S}/\text{cm}$ ) and dissolved metal concentrations ( $\text{mg}/\text{L}$ ) in the streams of Ecoregions 69 and 70 in West Virginia. All variables are logarithm transformed. The smooth lines represent the locally weighted scatter plot smoothing (LOWESS) lines (span =  $2/3$ ).



**Figure 11d. Total metals.** Matrix of scatter plots and absolute Spearman correlation coefficients between conductivity ( $\mu\text{S}/\text{cm}$ ) and total metal concentrations ( $\text{mg}/\text{L}$ ) in the streams of Ecoregions 69 and 70 in West Virginia. All variables are logarithm transformed. The smooth lines represent the locally weighted scatter plot smoothing (LOWESS) lines (span =  $2/3$ ).



**Figure 11e. Other water quality parameters.** Matrix of scatter plots and absolute Spearman correlation coefficients between environmental variables in the streams of Ecoregions 69 and 70 in West Virginia. The smooth lines are locally weighted scatter plot smoothing (LOWESS) lines (span = 2/3). Conduct is logarithm transformed specific conductance ( $\mu\text{S}/\text{cm}$ ); Temp is water temperature ( $^{\circ}\text{C}$ ); RBP is Rapid Bioassessment (Habitat) Protocol score (possible range from 0 to 200); Fecal is logarithm transformed fecal coliform bacteria count (per 100 mL water); Watershed is logarithm transformed watershed area ( $\text{km}^2$ ); embeddedness is a parameter score from the Rapid Bioassessment Protocol (possible range from 0 to 20); DO is dissolved oxygen ( $\text{mg}/\text{L}$ ); TP is logarithm transformed total phosphorus ( $\text{mg}/\text{L}$ ); NO23 is logarithm-transformed nitrate and nitrite ( $\text{mg}/\text{L}$ ).

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## **APPENDIX A**

### **CAUSAL ASSESSMENT**

## 1    **ABSTRACT**

2           Because associations in the field are not necessarily causal, this appendix reviews the  
3 evidence that salts are a cause of impairment of aquatic macroinvertebrates in streams in  
4 Ecoregions 69 and 70 of West Virginia. The goal is to establish that salts are a general cause,  
5 not that they cause all impairments, nor that there are no other causes of impairment, nor that  
6 they cause the impairment at any particular site. The evidence is organized in terms of six  
7 characteristics of causation. The inferential approach is to weigh the body of evidence, as is  
8 done in epidemiology. The results are positive; the available evidence indicates that salts, as  
9 measured by conductivity, are a common cause of impairment of aquatic macroinvertebrates in  
10 the region of concern. The following appendix (B) addresses the potential for other variables to  
11 confound the effects of salts.

### 12 13    **A.1.   INTRODUCTION**

14           To assure that that the association of conductivity with the extirpation of aquatic taxa  
15 reflects a causal relationship, we use epidemiological arguments. The most widely accepted  
16 epidemiological approach was first used to show that smoking causes cancer in humans (Hill,  
17 1965; U.S. DHEW, 1964). It consists of weighing the available evidence on the basis of causal  
18 considerations. As in the case of tobacco smoke, conductivity represents a mixture, and its  
19 effects are not necessarily immediately apparent following exposure. Hill's approach for  
20 establishing a probable causal relationship has been adapted for ecological applications (Fox,  
21 1991; U.S. EPA, 2000; Suter et al., 2002; Cormier et al., 2010). We rely on the same approach  
22 to demonstrate that mixtures of ions that elevate conductivity in streams in the Mountain and  
23 Plateau Regions of Central Appalachia are causing local extirpation of species.

24           The causal characteristics used in this assessment are described in Cormier et al. (2010)  
25 (see Table A-1). Each causal characteristic is defined and related to Hill's considerations and to  
26 the types of evidence in the *Stressor Identification (SI) Guidance* (U.S. EPA, 2000) and the  
27 Causal Analysis/Diagnosis Decision Information System (CADDIS) Web site  
28 (<http://www.epa.gov/caddis>). The SI and CADDIS types of evidence indicate the types of  
29 information that are potentially available to demonstrate characteristics of causation from  
30 Cormier et al. (2010). Hill's considerations are a mixture of types of evidence, sources of  
31 information, and quality of information, but they are included because they are traditional.

#### 32 33    **A.1.1.   Assessment Endpoints**

34           This causal assessment evaluates whether the aqueous salinity, as measured by  
35 conductivity, is capable of causing local extirpation of stream biota in an area of the Central

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Appalachia including Ecoregions 69 (Central Appalachia) and 70 (Western Alleghany Plateau) (Woods et al., 1996). These regions include parts of the states of Ohio, Pennsylvania, Maryland, West Virginia, Kentucky, and Tennessee. The entities of concern are benthic invertebrates, possibly including rare and threatened species. The effect is local extirpation from streams in their natural range. Depending on the type of evidence, different biological measurement endpoints are used. In particular, the number of ephemeropteran genera is used in many of the quantitative analyses, because most of the sensitive genera are Ephemeroptera and the number of genera is a good summary of the consequences of extirpation. However, the assessment is of general causation in the regions of concern, not for any specific genus or location.

#### A.1.2. Data Sets

The same data sets used in the derivation of the aquatic life benchmark were used in the causal assessment, particularly the West Virginia Department of Environmental Protection's (WVDEP's) WABase. In addition, evidence was drawn from the literature involving laboratory studies, a data set from U.S. Environmental Protection Agency (U.S. EPA) Region 3 described in Pond et al. (2008a), and geographic information, and related information described in Appendix F.

#### A.1.3. Weighting

The evidence is weighted using a system of plus (+) for supporting conductivity as a cause, minus (–) for weakening and zero (0) for no effect. (Both neutral evidence and ambiguous evidence have no effect on the inference.) One to three plus or minus symbols are used to indicate the weight of a piece of evidence.

+++ or ---	Convincingly supports or weakens
++ or --	Strongly supports or weakens
+ or -	Somewhat supports or weakens
0	No effect

Note that these scores are for particular pieces of evidence, not for causation as a whole. For example, a particular study may convincingly demonstrate that a source exists that is associated with elevated conductivity in the region, so it is scored + + +, but alone it is not convincing evidence that conductivity causes extirpation of biota.

Any relevant evidence receives a single plus, minus, or zero to register the evidence and to indicate a decreased or increased support for a causal relationship (see Table A-2). The

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1 strength of evidence is considered next. The strength of a relationship is indicated by the  
2 magnitude of a measure of association (e.g., a correlation coefficient) or the number of  
3 relationships that display the causal characteristic. After strength, the other possible unit of  
4 weight is assigned depending on causal characteristic and on the type of evidence. Additional  
5 considerations that may result in a higher score are presented in Table A-3.

## 7 **A.2. EVIDENCE OF CHARACTERISTICS OF CAUSATION**

### 8 **A.2.1. Co-occurrence**

9 Because causation requires that causal agents interact with unaffected entities; they must  
10 co-occur in space and time. Co-occurrence corresponds to Hill's *consistency*, SI's  
11 *co-occurrence*, and CADDIS's *co-occurrence in space and time*.

#### 13 **A.2.1.1. Correlation of Cause and Effect**

14 In the Watershed Assessment Branch Data Base (WABbase), conductivity and the  
15 number of ephemeropteran genera were moderately correlated ( $r = -0.63$ ) (see Figure A-1).  
16 This relationship holds even when elevated levels of potential alternative causes (confounders)  
17 are removed (see Figure A-2). In the data set created by Pond et al. (2008a), ephemeropteran  
18 genera and conductivity were highly correlated ( $r = -0.90$ ).

#### 20 **A.2.1.2. Contingency Table**

21 We constructed a contingency table of the presence of Ephemeroptera at sites near  
22 background conductivity ( $<200 \mu\text{S/cm}$ ) and higher conductivities ( $>1,500 \mu\text{S/cm}$ ) and recorded  
23 the ratio of presence or absence of mayflies (see Table A-4). It shows that mayflies co-occur  
24 with low conductivity but that all mayfly species are absent from more than  $\frac{3}{4}$  of sites where  
25 conductivity is high. This analysis supplements the correlations by emphasizing the difference  
26 between high and low conductivity sites with respect to a clear endpoint, the absence of all  
27 Ephemeroptera.

28 We also compared the number of genera at sites with lower conductivities ( $<200 \mu\text{S/cm}$ )  
29 and higher conductivities ( $>1,500 \mu\text{S/cm}$ ) with and without the co-occurrence of other  
30 parameters that are somewhat correlated with conductivity or are known biological stressors (see  
31 Tables B-1, B-2, B-3, and B-4). Whatever the level of the other parameter, when conductivity  
32 was low, Ephemeroptera were well represented and occurred less often or not at all at high  
33 conductivity. Hence, the potentially confounding agents were not responsible for the observed  
34 co-occurrence of conductivity and biological impairments. Other analyses of potential  
35 confounders are described in Appendix B on confounding.

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### 1    **A.2.1.3.    *Co-occurrence in Paired Watersheds Over Time***

2            Conductivity is shown to increase after the construction of valley fill coal mining  
3 operations, and the number of ephemeropteran genera is low relative to a paired unmined  
4 watershed (see Table A-5).

A.2.1. Summary. In sum, when conductivity is low, the number of genera is high. Even when other stressors are absent, where conductivity is high, the number of genera is low (see Figure A-2). The evidence for co-occurrence of conductivity with biological effects is strong, relevant, consistent, and of high quality and is, therefore, conclusive (see Table A-6).

### 7    **A.2.2.    *Preceding Causation***

8            Each causal relationship is a result of a web of preceding cause and effect relationships  
9 that begin with sources and include pathways of transport, transformation, and exposure.  
10 Evidence of sources of a causal agent increases confidence that the causal event actually  
11 occurred and was not a result of a measurement error, chance, or hoax (Bunge, 1979). Although  
12 preceding causation was not recognized by Hill, it corresponds to a type of evidence in the  
13 U.S. EPA's SI and CADDIS process, *causal pathway*.

#### 15    **A.2.2.1.    *Complete Source to Cause Pathway***

16            Because exposure to aqueous salts does not require transport or transformation (i.e.,  
17 organisms are directly exposed to salts in water immediately below sources), only evidence of  
18 the occurrence of sources is relevant. Potential sources of increased conductivity in the region  
19 include surface and underground coal mining, effluent from coal preparation plants and  
20 associated slurry impoundments, effluent from coal fly ash impoundments, winter road  
21 maintenance, brines from natural gas and coalbed methane drilling operations, treatment of waste  
22 water, human and animal waste, scrubbers at coal fired electric plants, and demineralization of  
23 crushed rock (Ziegler et al., 2007). The ionic composition of these waters is not uniform (see  
24 Table A-7). In particular, bicarbonate and sulfate are the dominant anions in streams at mined  
25 and unmined sites, but Marcellus Shale brine is almost entirely chloride salts. However, only  
26 four sites were found to have elevated conductivity with high chloride and low sulfate, so shale  
27 brines are rarely the sole dominant source of conductivity (see Section 2.3).

#### 29    **A.2.2.2.    *Evidence from Literature***

30            High conductivity leachate has been shown to flow from valley fills created during coal  
31 mining operations (Bryant et al., 2002; Merricks et al., 2007). In contrast, conductivity increases  
32 only slightly following clear-cutting and burning. Dissolved mineral loading may be increased

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1 slightly by harvesting but also declines quickly as vegetation re-establishes (Swank and  
2 Douglass, 1977). Golladay (1988) and Arthur et al. (1998) found increases in nitrogen and  
3 phosphorus export in logged catchments in the Appalachians but minor differences in calcium,  
4 potassium, or sulfate concentrations between logged and undisturbed watersheds. Likens et al.  
5 (1970) actually found sulfate concentrations to decrease following clear cutting and experimental  
6 suppression of forest growth by herbicides.

#### 8 **A.2.2.3. *Co-occurrence of Sources and Conductivity***

9 Conductivity increases where surface mining operations occur in a watershed and not in  
10 an adjacent unmined watershed (see Table A-5) and are higher overall in mined watersheds with  
11 valley fill than in unmined watersheds (see Table A-7).

#### 13 **A.2.2.4. *Characteristic Composition***

14 Correlation and regression analyses suggest that, in Ecoregions 69 and 70, conductivities  
15 above 500  $\mu\text{S}/\text{cm}$  contain high levels of the ions of  $\text{Ca}^{2+}$ ,  $\text{HCO}_3^-$ ,  $\text{Mg}^{2+}$ , and  $\text{SO}_4^{2-}$  (see  
16 Figure 10a–b) which is consistent with large scale surface coal mining and valley fill sources  
17 (Pond et al., 2008a). In contrast, the dominant ions of municipal waste water and of Marcellus  
18 Shale brine are  $\text{Na}^+$  and  $\text{Cl}^-$ , which rarely dominate conductivity in those regions (see Section 2.3  
19 and Table A-7). Therefore, the causal assessment relates primarily to mixtures of salts typical of  
20 alkaline coal mine drainage and associated valley fill discharges.

#### 22 **A.2.2.5. *Correlation of Conductivity with Sources***

23 Scatter plots of conductivity levels were generated for seven land cover classifications:  
24 open water, agriculture, residential, barren, valley fill, abandoned mine lands, and forested (see  
25 Appendix F for methods). From 2,151 sites in Ecoregion 69D described in the WVDEP  
26 WABbase, 191  $<20 \text{ km}^2$  watersheds were found for which there were macroinvertebrate samples  
27 identified to the genus level with at least one chemistry sample and TMDL land cover  
28 information. Small  $<20 \text{ km}^2$  subwatersheds were selected to reduce confounding from multiple  
29 sources. These subwatersheds drained into the Coal, Upper Kanawha, Gauley, and New Rivers  
30 (see Figure F-2. Land use and land cover were generated from publically available databases  
31 (see Appendix F). Land use and land cover were arc sine square root transformed to better  
32 depict the upper and lower portions of the distribution. Scatter plots and Spearman rank  
33 correlations of six land use categories and conductivity are shown in Figure A-3.

34 Although conductivity typically increases with increasing land use (Herlihy et al., 1998),  
35 the densities of agricultural and urban land cover were relatively low, and a clear pattern of

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1 increasing conductivity and increasing land use is not seen. At relatively low urban land use, the  
2 range of conductivity is highly variable (see Figure A-3). This may be caused by unknown mine  
3 drainage, deep mine break-outs, road applications, poor infrastructure condition (e.g., leaking  
4 sewers or combined sewers), or other practices. In contrast, there is a clear pattern of increasing  
5 conductivity as percent area in valley fill increases, and decreasing conductivity with increasing  
6 forest cover (see Figure A-3).

A.2.2. Summary. In sum, large scale surface mining and associated valley fills constitute a common and long-term source of high conductivity water in this region. The evidence for this source is abundant and of high quality. Hence, the evidence of preceding causation leading to high conductivity is conclusive (see Table A-8).

### 8 9 **A.2.3. Interaction and Physiological Mechanisms**

10 Causal agents alter affected entities by interacting with them through a physical  
11 mechanism. Evidence that a mechanism of interaction exists for a proposed causal relationship  
12 strengthens the argument for that relationship. This characteristic corresponds to Hill's  
13 *plausibility*, SI's *mechanism*, and CADDIS's *mechanistically plausible cause*.

#### 14 15 **A.2.3.1. Mechanism of Exposure**

16 Aqueous salts are dissolved ions that are readily available for uptake by aquatic  
17 organisms as they pass over their respiratory surfaces.

#### 18 19 **A.2.3.2. Mechanism of Effect**

20 The internal fluids of freshwater organisms are saltier than the water in which they live.  
21 As a result, freshwater organisms must use many physical structures and physiological  
22 mechanisms to maintain a balance of water content and ionic content. To maintain the balance  
23 of ions, they excrete hypotonic urine; possess impermeable scales, cuticles or exoskeletons; and  
24 use semipermeable membranes to redistribute ions (Bradley, 2009, Evans, 2008a, b; Wood and  
25 Shuttleworth, 2008; Thorp and Covich, 2001). Other methods of absorption include rectal  
26 pumping of water in Odonates and drinking by Megalopterans and Coleopterans. Anion, cation,  
27 and proton transport include passive, active, uniport, and co-transport (Nelson and Cox, 2005).  
28 Many freshwater invertebrates have chloride cells that actively take up chloride and other ions  
29 through gills (Komnick, 1977; Bradley, 2009). Members of the orders Ephemeroptera,  
30 Plecoptera, and Heteroptera have chloride cells on their body surfaces. Some dipterans and a  
31 few Trichopterans have chloride epithelia, and anal papillae are present on other members of  
32 these orders.

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1 Numerous specific mechanisms are involved in the toxicity of high-conductivity  
2 solutions; one is discussed here for the sake of illustration. The ion regulation system includes  
3 antiport anion exchange proteins that co-transport  $\text{Cl}^-$  against the concentration gradient into the  
4 cell simultaneously with  $\text{HCO}_3^-$  down the concentration gradient and out of the cell (Nelson and  
5 Cox, 2005; Bradley 2009). If external  $\text{HCO}_3^-$  is high, the gradient is not favorable for  $\text{Cl}^-$  uptake  
6 (Avenet and Lingnon, 1985).

7 Some physiological processes are especially dependent on proper ionic balance. These  
8 include nerve conduction, muscle contraction, and secretion. Reproduction, including  
9 fertilization, polymerization of egg mass coverings, and embryonic development depend on ionic  
10 balance, graphically illustrated by the swelling of fish eggs upon fertilization (Tarin et al., 2000).  
11 At the organismal level, effects of aqueous salts on aquatic arthropods include mortality (Kefford  
12 et al., 2003, 2005a) and reduced growth, reproduction, and hatching success (Clark et al., 2004a;  
13 Hassell et al., 2006; Kefford and Nugegoda, 2005; Kefford et al., 2004, 2006, 2007; Nielsen et  
14 al., 2003; Brock et al., 2005). These effects strongly suggest that population density can be  
15 reduced over generations of persistent exposure to elevated conductivity (Zalizniak et al., 2007).  
16

A.2.3. Summary. In sum, aquatic organisms are directly exposed to aqueous salts, and the relative amounts and concentration of salts may exceed the capacity of organisms to regulate their internal ionic composition. The importance of osmoregulation and ionic homeostasis has been demonstrated in diverse animal models with results published in the peer-reviewed literature. The evidence is drawn from a long history of physiological investigations (see Table A-9).

#### 17 18 **A.2.4. Specific Alteration**

19 A specific cause induces a specific effect in particular receptors. This alteration is  
20 obscured in many studies by broad definitions of causes and effects, but, when a specific effect  
21 of a cause is characterized, it strengthens the evidence for a causal relationship. If the specific  
22 effect of a cause occurs with no other causes, it can be diagnostic of that cause. This  
23 characteristic corresponds to *specificity* in Hill's considerations and in the SI's types of evidence,  
24 and to *symptoms* in CADDIS.  
25

##### 26 **A.2.4.1. *Specificity of Genera***

27 In a paper focusing on mayflies, principal component analysis sorted mined and  
28 residential sites from reference sites primarily on the basis of specific conductance and pH  
29 (Pond, 2009). In the same study, a nonmetric multidimensional scaling model strongly  
30 associated Ephemerella, Drunella, Cinygmula, Epeorus, and Ameletus with the low conductivity

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reference sites and no mayflies or *Caenis*, *Baetis*, *Isonychia*, and *Stenonema* with the higher conductivity sites. The first group has  $XC_{95} < 600 \mu\text{S}/\text{cm}$ , and the second group of tolerant mayflies had  $XC_{95} > 729 \mu\text{S}/\text{cm}$ .

The derivation of 95<sup>th</sup> percentile extirpation concentration ( $XC_{95}$ ) values and species sensitivity distributions in this document demonstrated that a characteristic set of genera (primarily Ephemeroptera) were extirpated at relatively low conductivities and others were resistant. The relative sensitivities are consistent with the findings of Pond et al. (2008a) and with analyses of data from Kentucky (see Appendix E). This is not meant to suggest that conductivity is the only possible cause of loss of these genera. Rather, it indicates that the loss of those genera consistently occurs where conductivity is elevated. If a random set of genera were lost, it might suggest that various causes were acting that co-occur with elevated conductivity, but that was not the case.

#### **A.2.4.2. *Specificity of Assemblages***

Using an independent data set collected in West Virginia, nonmetric multidimensional scaling was applied to biological metrics, and sites were sorted into distinct ordination space characterized by low, medium, and highly elevated conductivities associated with surface mines with valley fill (Pond et al., 2008a).

A.2.4. Summary. In sum, some genera are sensitive to conductivity, and others are not. The evidence for effects specific to high conductivity is reasonably strong, relevant, consistent, and of high quality and is, therefore, supportive (see Table A-10).

#### **A.2.5. Sufficiency**

For an effect to occur, sufficiently susceptible entities must experience a sufficient magnitude of exposure. This characteristic corresponds to *biological gradient* in Hill's considerations. In SI and CADDIS, multiple types of evidence may demonstrate sufficiency including *stressor-response in the field*, *laboratory tests of site media*, *manipulation of exposure* and *stressor-response from laboratory studies*.

##### **A.2.5.1. *Laboratory Tests of Defined Ion Mixtures***

Mount et al. (1997) tested the acute lethality of several mixtures of salts to two planktonic crustaceans (*Ceriodaphnia dubia* and *Daphnia magna*) and a fish (*Pimephales promelas*). A mixture of  $\text{K}_2\text{SO}_4$  and  $\text{KHCO}_3$  salts was the most toxic combination of salts tested in the study. The 48-hour  $\text{LC}_{50}$  for *Ceriodaphnia* with  $\text{K}_2\text{SO}_4$  and  $\text{KHCO}_3$  corresponds to  $438 \mu\text{S}/\text{cm}$ . The 96-hour  $\text{LC}_{50}$  for *Pimephales promelas* also with  $\text{K}_2\text{SO}_4$  and  $\text{KHCO}_3$  corresponds to

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1 1,082  $\mu\text{S}/\text{cm}$ . The ion matrix of alkaline mine drainage normally contains little  $\text{K}^+$ , and instead,  
2  $\text{Ca}^{2+}$  and  $\text{Mg}^{2+}$  are the dominant cations. Conductivity measurements below some valley fills  
3 were greater than 4,000  $\mu\text{S}/\text{cm}$ . This study demonstrates that mixtures of specific salts can be  
4 acutely lethal at concentrations corresponding to conductivities measured in the region. The  
5 Mount et al. (1997) model has been used to estimate that salt mixtures in some streams below  
6 valley fills are sufficient to cause acute lethality in *Ceriodaphnia* (U.S. EPA, 2009). However,  
7 these tests are marginally relevant. The crustaceans are not taxonomically similar to the  
8 invertebrate species that are affected, the 48-hour test durations are far shorter than the life-cycle  
9 exposures in the field, and the effect (acute lethality) is unlikely to be the cause of  
10 population-level effects in the field. Life-cycle effects on local insects are likely to occur at  
11 much lower levels of conductivity (U.S. EPA, 2009). However, these tests do indicate that the  
12 ion mixture could be toxic to common surrogate laboratory organisms used to evaluate toxicity.

#### 14 **A.2.5.2. Laboratory Tests of Mine Discharges**

15 Kennedy et al. (2003, 2004, 2005) tested coal mine discharge waters in Ohio with  
16 *Ceriodaphnia dubia* and a mayfly (*Isonychia bicolor*). In 7-day lethality tests, the mayfly was  
17 about three times as sensitive as the crustacean. Lowest observed effect concentrations (LOECs)  
18 for survival of mayflies (mid to late-instars) at 20°C occurred at 1,562, 966, and 987  $\mu\text{S}/\text{cm}$  in  
19 three tests. These values bracket the *Isonychia*  $\text{XC}_{95}$  of 1,177  $\mu\text{S}/\text{cm}$ . *Ceriodaphnia* tests with  
20 simulated effluent containing only major ions showed that the toxicity of this effluent was not  
21 due to heavy metals or Se (Kennedy et al., 2005).

22 Echols et al. (2009) performed 10–14 day toxicity tests of coal processing effluent from  
23 Virginia with *Isonychia bicolor*. They obtained LOEC values for survivorship in three tests of  
24 1,508 to 4,101  $\mu\text{S}/\text{cm}$ . The lower toxicity of these waters may be due to the dominance of  
25 sodium, which has the lowest toxicity of the common cations (Mount et al., 1997). In any case, it  
26 is not surprising that these acute lethality tests yield higher conductivity levels than the *Isonychia*  
27  $\text{XC}_{95}$  (1,177  $\mu\text{S}/\text{cm}$ ) which is a result of full life-cycle exposures and effects. In particular, in the  
28 final test which yielded the lowest LOEC, survival at the end of the test was approximately 25%  
29 and still declining. The effluent contained no detectable toxic trace metals or metalloids except  
30 selenium (8.5  $\mu\text{g}/\text{L}$ ), so the authors stated that the toxicity was likely due to salinity.

#### 32 **A.2.5.3. Laboratory Tests of Ambient Waters**

33 Waters from below valley fills in the region of concern were tested by Merricks et al.  
34 (2007). *Ceriodaphnia dubia*  $\text{LC}_{50}$  values in 48-hour tests were established for some but not all  
35 waters from Lavender Fork with undiluted concentrations of 2,497–3,050  $\mu\text{S}/\text{cm}$ . These tests

1 used relevant mixtures of ions, but the test species, duration and endpoint have low relevance  
2 and are likely to underestimate toxicity in the field.

#### 3 **A.2.5.4. *Field Exposure-Response Relationships***

4 As Hill suggested, a biological gradient in the field suggests that the exposures reach  
5 levels that are sufficient to cause effects. Pond et al. (2008a, b) reported that the number of taxa  
6 decreases as conductivity increases or as the amount of surface mining and associated valley fills  
7 increases. Analyses conducted for this report using the WABbase data sets show that as  
8 conductivity increases the total number of genera and the number of ephemeropteran genera  
9 decrease at conductivity levels shown to extirpate sensitive genera (see Figure A-1). This  
10 analysis shows not only the co-occurrence of elevated conductivity and loss of stream biota but  
11 also that there is a regular exposure-response relationship that extends to the lowest observed  
12 concentrations (evidence of sufficiency). The same data set was also modeled by partitioning for  
13 potential confounding parameters. Streams with higher temperatures ( $>22^{\circ}\text{C}$ ), low pH ( $<6$ ), poor  
14 habitat ( $<135$ ) and high fecal coliform ( $>400$  colonies/100 mL) were excluded. The effect of  
15 conductivity was still strong (see Figure A-2). Also, the distributions of individual genera show  
16 that as conductivity increases the occurrence and capture probability decreases for many genera  
17 (see Appendix D).

#### 19 **A.2.5.5. *General Knowledge***

20 The susceptibility of organisms and communities is a function of genetic, evolutionary,  
21 developmental, and physiological legacies. Numerous studies have characterized the  
22 disappearance of freshwater taxa with increasing salt concentration (Remane, 1971; Wetzel,  
23 2001). Species native to the Mid-Atlantic Highlands (Ecoregions 69 and 70) have evolved for  
24 very low conductivity water and are expected to decline as salinity increases above background.  
25 Conductivities below  $70\ \mu\text{S}/\text{cm}$  were common in forested areas.

A.2.5. Summary. In sum, the available evidence suggests that conductivities in the region of concern reach levels that are sufficient to cause effects on stream communities (see Table A-11). Most laboratory toxicity tests have been conducted with species, effects and exposures that have low relevance and sensitivity to salinity. However, they still show that ambient salinities observed in the regions of concern can cause severe effects. More to the point, saline coal mine effluents from the region are lethal to a mayfly species at conductivities similar to its extirpation concentration. Correlations of conductivity and stream biological metrics confirm that conductivity is strongly associated with gradients of biological response down to the levels where sensitive genera are extirpated. These relationships are strong even when other stressors were present. Finally, general studies of the effects on aquatic organisms of changes in salinity suggest that the observed magnitude of increases in salinity in these regions is sufficient to cause the extirpation of some species, but the studies were not conducted at levels as low as those occurring in this region.

#### A.2.6. Time Order

Logically, a causal event occurs before an effect is observed. Evidence of time order is provided by changes in the invertebrate assemblages after the introduction of a source that increased conductivity. This characteristic corresponds to *temporality* in Hill's considerations and in the SI types of evidence and to *temporal sequence* in CADDIS.

We could not obtain conductivity and biological survey data for before and after a valley fill or other source of saline effluents began operation. Hence, this characteristic of causation is scored No Evidence (NE).

#### A.2.7. Evaluation of the Body of Evidence

Conclusions concerning causality are based on the weight of evidence from all types of evidence that support or weaken all of the characteristics of causation. The property of the body of evidence was termed *coherence* by Hill. In SI and CADDIS, it is divided into two considerations: the *consistency* of evidence and the *coherence* of evidence (i.e., the reasonableness of explanations of any inconsistencies in the evidence).

This causal assessment found that the available evidence supports a causal relationship between mixtures of matrix ions in streams of Ecoregions 69 and 70 and biological impairments. That conclusion is based on evidence showing that the relationship of conductivity to the loss of aquatic genera has the characteristics of causation.

1. Co-occurrence—The loss of genera occurs where conductivity is high even when potential confounding causes are low but is rare when conductivity is low (+ + +).



2. Preceding Causation—Sources of conductivity are present and are shown to increase stream conductivity in the region (+ + +).
3. Interaction—Aquatic organisms are directly exposed to dissolved salts. Physiological studies over the last 100 years have documented the many ways that physiological functions of all organisms are affected by excess salt or the combinations of ions for which they do not have physiological capacity or mechanisms to regulate (+).
4. Alteration—Some genera and assemblages are affected at sites with higher conductivity while others are not. These differences are characteristic of high conductivity (+ +).
5. Sufficiency—Increased exposure in both concentration and duration to salt affects invertebrates based on both field and laboratory analyses (+ + +).
6. Time order—Conductivity increases, and local extirpation occurs after mining permits are issued, but before and after data are not available (NE).

Other potential causes of the loss of genera in the region include elevated temperatures associated with loss of shade or increased impervious surfaces, siltation from various land use activities, low pH from atmospheric deposition and abandoned mines, aluminum toxicity from abandoned mines, and nutrient enrichment from various sources. Se toxicity has also been implicated. When these causes are minimized, a relationship between conductivity and mayfly richness is still evident (see Appendix B).

This causal assessment does not attempt to identify the constituents of the mixture that account for the effects. Constituents of the mixture in neutral and somewhat alkaline waters that increase as conductivity increases are all considered as contributing to the local extirpation of genera in the region of concern. The dominant ions include  $\text{HCO}_3^-$ ,  $\text{SO}_4^{2-}$ ,  $\text{Ca}^{2+}$ ,  $\text{K}^+$ , and  $\text{Mg}^{2+}$ .

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14

**Table A-1. Definitions of causal characteristics**

<b>Characteristic</b>	<b>Description</b>
Co-occurrence	The cause co-occurs with the unaffected entity in space and time
Preceding causation	Each causal relationship is a result of a larger web of cause and effect relationships
Time order	The cause precedes the effect
Interaction	The cause physically interacts with the entity in a way that induces the effect
Alteration	The entity is changed by the interaction with the cause
Sufficiency	The intensity, frequency, and duration of the cause are adequate, and the entity is susceptible to produce the type and magnitude of the effect

**Table A-2. Relationships between qualities of evidence and scores for weighing evidence**

<b>Qualities of the evidence</b>	<b>Score, not to exceed three minus or three plus</b>
Logical implications	+, 0, -
Strength	Increase score
Other qualities	Increase score

**Table A-3. Other considerations used to weight the evidence concerning the influence of potentially confounding variables**

<b>Quality of evidence</b>	<b>Alternative outcomes</b>
Directness of cause	Proximate cause, sources, or intermediate causal connections
Specificity	Effect attributable to only one cause or to multiple causes
Relevance to effect	From the case or from other similar situations
Nature of the association	Quantitative or qualitative
Independence of association	Independent or confounded

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**Table A-4. Presence of mayflies contingent on stream conductivity (data from WABbase)**

	Mayflies present	Mayflies absent	Total
Near background conductivity (<200 $\mu\text{S}/\text{cm}$ )	889 96.2%	35 3.8%	924
High conductivity ( $\geq 1,500$ $\mu\text{S}/\text{cm}$ )	28 21.7%	101 78.3%	129
Total	917	136	1,053

**Table A-5. Temporal increase of conductivity 2 years after permitting of mining operations**

	Never mined Ash Fork			Permit 1994, 1996 Boardtree Branch			Permit 1996; Stillhouse		
	1998	2003	2006/07	1998	2003	2007	1998	2003	2007
$\mu\text{S}/\text{cm}$	44 <sup>a</sup>	39 <sup>b</sup>	42 <sup>b</sup> /39 <sup>a</sup>	1,396 <sup>a</sup>	3,015 <sup>b</sup>	3,390 <sup>a</sup>	511 <sup>a</sup>	3,200 <sup>b</sup>	3,970 <sup>a</sup>
% E		27.23	29.21			1.23			0
# E		6	4			2			0
# P		5	6			0			0
# EPT		20	14			5			3
TT		41	24			20			8

<sup>a</sup>Single measurement.

<sup>b</sup>Mean value.

E = Ephemeroptera; P = Plecoptera; T = Trichoptera; TT = total taxa.

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**Table A-6. Summary of evidences and scores for co-occurrence**

Type of evidence	Evidence	Score
Correlation of cause and effect	Ephemeroptera were correlated with conductivity in two studies $r = -0.63$ (see Figure A-1) and $r = -0.90$ . This is strong quantitative evidence from multiple studies.	+++
Contingency table	The contingency table (see Table A-4) provides strong quantitative evidence that high conductivity is strongly associated with severe effects (Ephemeroptera absent at >75% of sites).	++
Co-occurrence in paired watersheds over time	24% to 100% difference (see Table A-5) is large and quantitative.	++
Overall score	Relevant, strong, consistent.	+++

**Table A-7. Total cations and anions measured in water originating from surface mined sites with valley fills, unmined sites, or Marcellus Shale brine.** Individual ions are presented as a fraction of the total cations or anions. For mined sites,  $n = 13$ ; unmined sites,  $n = 7$ ; Marcellus Shale brine,  $n = 3$ . Measurements of  $\text{HCO}_3^-$  and  $\text{NO}_3^- \text{N}$  were not available for Marcellus Shale brine sites.

	Mined (Valley Fill)			Unmined			Marcellus Shale Brine		
	Mean	Median	Range	Mean	Median	Range	Mean	Median	Range
<b>Total Cations (mg/L)</b>	282.4	238.9	72.7–515.2	15.7	15.9	7.0–25.6	23,862.0	21,719.0	8,650.0–41,217.0
Ca	0.48	0.48	0.42–0.55	0.46	0.46	0.37–0.63	0.24	0.23	0.20–0.28
Mg	0.42	0.42	0.28–0.51	0.28	0.27	0.22–0.36	0.02	0.02	0.02–0.02
K	0.04	0.04	0.02–0.05	0.11	0.11	0.06–0.18	0.02	0.01	0.005–0.05
Na	0.06	0.03	0.02–0.25	0.15	0.14	0.06–0.24	0.72	0.70	0.69–0.78
<b>Total Anions (mg/L)</b>	926.8	730.4	228.1–1,734.4	44.7	47.2	21.9–66.5	28,296.1 <sup>a</sup>	18,620.8 <sup>a</sup>	14,326.3–51,941.3 <sup>a</sup>
<sup>b</sup> $\text{HCO}_3^-$	0.25	0.25	0.06–0.48	0.54	0.57	0.34–0.66	NA	NA	NA
Cl	0.0076	0.0042	0.0032–0.0036	0.07	0.06	0.04–0.11	0.999	0.999	0.998–0.999
$\text{NO}_3^- \text{N}$	0.0036	0.0031	0.0013–0.011	0.01	0.01	0.002–0.04	NA	NA	NA
$\text{SO}_4$	0.73	0.74	0.51–0.93	0.38	0.35	0.29–0.51	0.0013	0.0011	0.0011–0.0016

<sup>a</sup>Total anions includes only  $\text{Cl}^-$  and  $\text{SO}_4^{2-}$ .

<sup>b</sup> $\text{HCO}_3^-$  converted from measurement of alkalinity as  $\text{CaCO}_3$ .

NA = not applicable due to lack of data.



**Table A-8. Summary of evidences and scores for preceding causation**

Type of evidence	Evidence	Score
Complete source-to-cause pathway	Sources are present, and no intermediate steps in the pathway are required.	+
Correlation of conductivity with sources	Figure A-3, $r = 0.61$ . This is moderately strong quantitative evidence from the case.	++
Evidence from literature	Multiple publications link conductivity to sources in the region and eliminate some other land uses as sources.	+
Co-occurrence of sources and conductivity	When valley fills are present, conductivity is 12- to 90-fold greater than at unmined sites (see Tables A-5 and A-7). This is strong quantitative evidence from the case.	++
Characteristic composition	Ambient mixtures of ions have characteristic compositions that can be associated with particular sources. Most sites with elevated conductivities have compositions characteristic of coal mining with valley fill. This is relevant but quantitatively weak evidence.	+
Overall score	Relevant, strong, consistent.	+++

**Table A-9. Summary of evidences and scores for interaction and physiological mechanism**

Type of evidence	Evidence	Score
Mechanism of exposure	Salts readily dissolve in water and interact directly with aquatic organisms.	+
Mechanism of effect	Many mechanistic studies show that osmoregulation and homeostasis of specific ions are sensitive to disruption, particularly in mayflies.	+
Direct evidence	No studies of ionic compensation are available for organisms in the region.	NE
Overall score	Relevant but not case-specific.	+

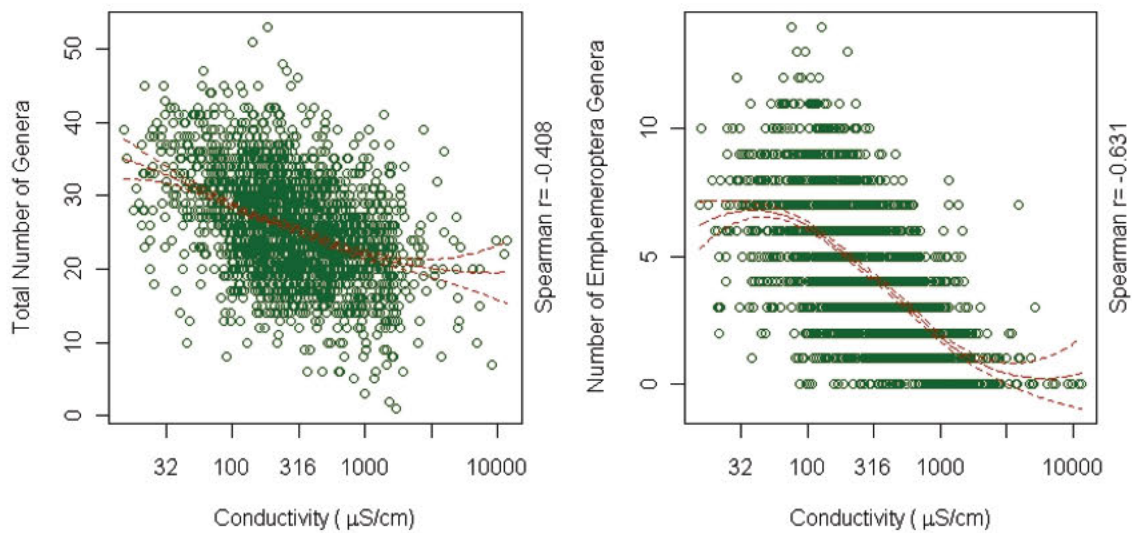
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**Table A-10. Summary of evidence and scores for specific alteration**

<b>Type of evidence</b>	<b>Evidence</b>	<b>Score</b>
Specificity of genera	Specific genera are consistently sensitive to conductivity. This quantitative evidence is independently confirmed.	+ +
Specificity of assemblage	A model based on specific biology discriminated effects of conductivity associated with mining.	+
Overall score for interaction	Relevant, independently confirmed, and consistent, but only two types of evidence.	+ +

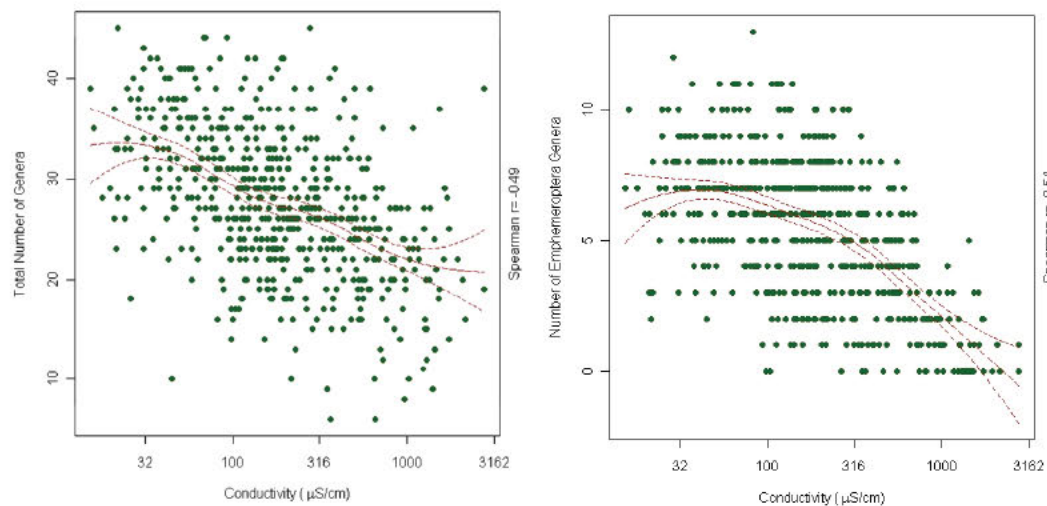
**Table A-11. Summary of evidence and scores for sufficiency**

Type of evidence	Evidence	Score
Laboratory tests of defined ion mixtures	The tests were high quality, but the species and durations have low relevance for determining the conductivity level at which effects occur, and the effect levels are supportive only if assumptions are made about acute/chronic and intertaxa extrapolations.	0
Laboratory tests of mine discharges	This evidence is relevant in that it comes from nonacid mine effluents in the region and includes an Ephemeropteran; but the ionic mixtures were somewhat different, the effect was lethality and the durations were short. The results for one set of tests matched the XC <sub>95</sub> for the test genus, but were higher for the other.	+
Laboratory tests of ambient waters	These tests showed acute lethality to an apparently resistant species at high conductivity levels. Its relevance is too low to support or weaken.	0
Field exposure-response relationships for Ephemeroptera	This is strong evidence because it is highly relevant, was obtained independently in two separate data sets, with moderate to strong correlations. It is not convincing in itself because of the potential for confounding, which is treated in Appendix B.	++
Field exposure-response relationships for genera	As conductivity increases, genera no longer are observed.	++
General knowledge	General knowledge indicates that salinity can cause the loss of species but does not indicate that the salinity levels observed in this case are sufficient.	0
Overall score	The exposure-response relationships in the field, with some support from laboratory studies, provide positive evidence that the conductivity levels observed are sufficient to cause the associated effects.	+++



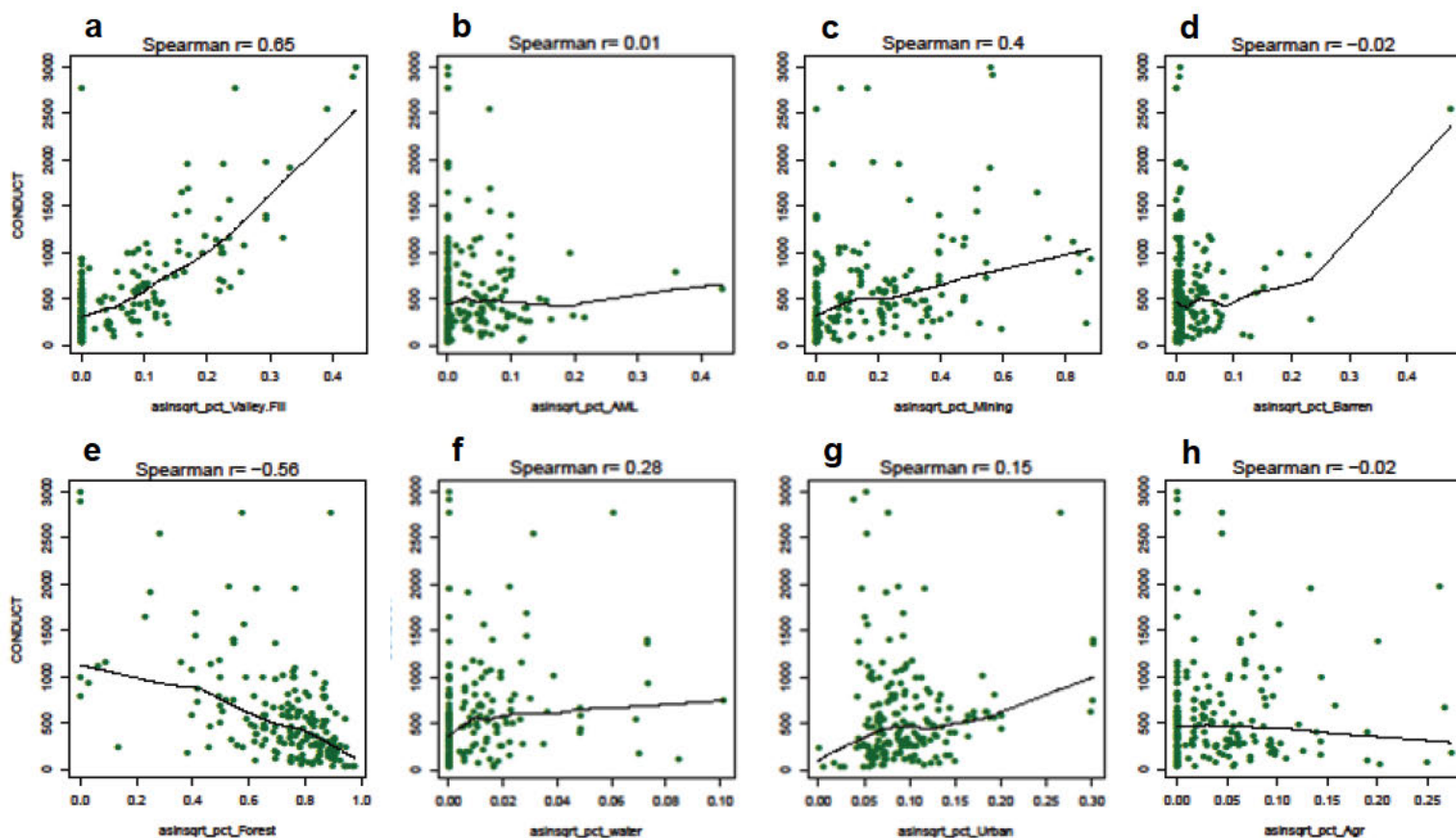
**Figure A-1. As conductivity increases, the number of total and ephemeropteran genera decrease.**

Data source: WABase



**Figure A-2. As conductivity increases, the number of total and ephemeropteran genera decrease even when potentially confounding parameters are minimized.** (Excluded: streams with higher temperatures [ $>22^{\circ}\text{C}$ ], low pH [ $<6$ ], poor habitat [ $<135$ ] and high fecal coliform [ $>400$  colonies/100 mL]).

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**Figure A-3. Conductivity associated with different land uses in 151 watersheds in Ecoregion 69D.** There is a clear pattern of increasing conductivity as percent area in valley fill increased, but no pattern with other land use. From left to right, they are (a) mountaintop mining-valley fill, (b) abandoned mine lands, (c) mined, (d) barren, (e) forested, (f) water, (g) urban/residential, and (h) agricultural. Land use and land cover were arc sine square root transformed to better depict the upper and lower portions of the distribution.

## **APPENDIX B**

### **CONFOUNDING**

## 1    **ABSTRACT**

2            The purpose of this appendix is to determine which, if any, of the variables that may  
3 co-occur with conductivity alter our ability to model the relationship between conductivity and  
4 occurrence of genera. The point was not to determine whether the confounders are general  
5 causes (i.e., can they cause impairments in the region of concern?).

6            The appendix addresses its purpose in two ways. First, it supports Appendix A by  
7 demonstrating that none of the potential confounders is responsible for the association between  
8 conductivity and biological effects. Second, it supports the development of the benchmark value  
9 by determining whether the confounders have significant influence on the causal relationship  
10 between salts and macroinvertebrate assemblages. The inference was performed by identifying  
11 potential confounders and then determining the occurrence and strength of ten types of evidence  
12 for confounding for each of them. The effect of confounders was found to be minimal and  
13 manageable. Potential confounding by low pH was minimized by removing sites with pH <6  
14 from the data set when calculating the aquatic life benchmark. The influence of Se could not be  
15 evaluated due to poor data and should be investigated. The signal from conductivity was strong  
16 so that other potential confounders that were not strongly influential could be ignored with  
17 reasonable or greater confidence. We do not argue that these variables have no influence, but  
18 their effects are minimal given the streams that would be affected by the aquatic life benchmark.

### 19 20    **B.1.    INTRODUCTION**

21            The goal of this analysis is not to eliminate confounding variables. They are natural  
22 variables such as temperature and habitat structure that cannot be literally eliminated like  
23 eliminating smokers in an epidemiological study. Nor is the goal to equate the levels of  
24 confounders to an ideal or pristine level. High conductivity effluents do not enter wilderness  
25 streams. Rather, the streams are subject to some level of disturbance. The goals are (1) to define  
26 a set of streams in which the effects of elevated conductivity can be identified without significant  
27 influence by confounding variables, and (2) to estimate conductivity levels that would protect  
28 against the unacceptable effects of salts in those streams (i.e., typical streams receiving high  
29 conductivity effluents in the region of concern).

30            Because of those goals and the nature of the data, it is not appropriate to use multivariate  
31 statistics to try to eliminate confounders. Multiple regression methods depend on assumptions of  
32 independence, additivity, and normality that are not met. Propensity scores depend on a  
33 counterfactual assumption (i.e., it assumes that the confounders can be different than they are).  
34 This condition is met in propensity score analyses of epidemiological or econometric studies in  
35 which, for example, a cancer patient could be a smoker or not or might live in a city or not. That

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counterfactual assumption is often not met by ecological data. In particular, the alkaline ions that contribute to elevated conductivity also contribute to raising the pH. Therefore, pH and conductivity are not mechanistically independent, and counterfactual assumptions cannot be applied. Attempts to statistically eliminate the influence of pH would artificially reduce the effects of salinity. However, the epidemiological weight-of-evidence approach used here can make use of the fact that, once we have eliminated acidic sites, the neutral to moderately alkaline pH levels that remain are not toxic to stream organisms.

Confounding is a bias in the analysis of causal relationships due to the influence of extraneous factors (confounders). Confounding occurs when a variable is correlated with both the cause and its effect. The correlations are usually due to a common source of multiple, potentially causal agents. However, they may be observed for other reasons (e.g., when one variable is a by-product of another) or due to chance associations.

Confounding may result in identification of a cause that is in fact a noncausal correlate. That possibility is commonly addressed by applying Hill's (1965) considerations or some equivalent set of criteria for causation as in Appendix A. This is done because statistics alone cannot determine the causal nature of relationships (Pearl, 2000; Stewart-Oaten, 1996).

Confounding can also bias a causal model resulting in uncertainty concerning the actual magnitude of the effects. A variety of approaches may be used to determine whether confounders significantly affect the results. They are related to three of the characteristics of causation used to determine that elevated conductivity is a cause of impairment of stream communities in Appendix A (co-occurrence, sufficiency, and alteration). We provide a relatively complete list, but we only used Evidence Types 1, 2, 3, 5, 6, and 8.

1. Co-occurrence of confounder and cause: Confounders are correlated with the cause of interest. A low correlation coefficient is evidence against the potential confounder.
2. Co-occurrence of confounder and effect: Potential confounders are correlated with the effect of interest. A low correlation coefficient is evidence against the potential confounder.
3. Co-occurrence of confounder and cause: Even when the confounder is not correlated with the cause of interest, it may be influential at extreme levels. A lack of influence at extreme levels of the cause and the potential confounder is evidence against the potential confounder.
4. Co-occurrence of confounder and effect: If the frequency of the effect does not diminish when the potential confounder is not present, the confounder can be discounted in that subset.
5. Sufficient confounder: The magnitude of the potential confounder (e.g., concentration of a co-contaminant) may be compared to exposure-response relationships from elsewhere

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(e.g., laboratory toxicity tests) to determine if the exposure to the potential confounder is sufficient. If it is not sufficient that is evidence that it is not acting as a confounder.

6. Sufficient confounder: If the confounder is estimated to be sufficient in a subset of cases, those cases may be removed from the data set, and the remaining set reanalyzed to determine the influence of their removal on the results.

7. Sufficient confounder: Multivariate statistical techniques may be used to estimate the magnitude of confounding or to adjust the causal model for confounding, if their assumptions hold.

8. Sufficient confounder: If the potential confounder occurs in a sufficiently small proportion of cases, it can be ignored.

9. Alteration: If a potential confounder has characteristic effects that are distinct from those of the cause of concern, then the absence of those effects can eliminate the potential confounder as a concern in either individual cases or the entire data set.

10. Alteration: If the effects are characteristic of the cause of concern and not of the potential confounder, then the potential confounder can be eliminated as a concern in either individual cases or the entire data set.

Weighing evidence for confounding differs from weighing evidence for causation. The causal assessment in Appendix A determines whether dissolved salts are an important cause of biological impairment in the region. This assessment of confounding takes the result of the causal assessment as a given and attempts to determine whether any of the known potential confounders interfere with estimating the effects of conductivity to a significant degree. That requires a different weighting and weighing method from the one in Appendix A, which would be used if the goal were to determine whether the potential confounder is itself a cause.

As in Appendix A, the number of ephemeropteran genera is used as a standard metric for the effects of conductivity, which may or may not be confounded. Because the sensitive genera are primarily Ephemeroptera and the endpoint effect is extirpation of 5% of genera, this is an appropriate metric.

## **B.2. WEIGHTING**

The evidence is weighted using a system of plus (+) for supporting the potential confounder (i.e., the evidence suggests that the potential confounder is actually causing the effect to a significant degree), minus (–) for weakening the potential confounder (i.e., the evidence suggests that the potential confounder does not contribute to the effect to a significant degree), and zero (0) for no effect. One to three plus or minus symbols are used to indicate the weight of a piece of evidence.

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+++	Convincingly supports or weakens
++	Strongly supports or weakens
+	Somewhat supports or weakens
0	No effect

Any relevant evidence receives a single plus, minus, or zero to register the evidence and to indicate a decreased or increased potential for confounding (see Table B-1). The strength of evidence is considered next. Criteria for scoring the strength of evidence are presented below for the common types. They were developed for transparency and consistency and are based on the authors' judgments. After strength, the other possible unit of weight is assigned depending on the type of evidence.

For co-occurrence (Evidence Types 1–4), strength or consistency of the association is the primary consideration. For comparison for any of the potential confounders, the correlation coefficient for conductivity and number of ephemeropteran genera is 0.63, a value in the upper end of the moderate range. Correlations, as measures of co-occurrence, can be scored as in Table B-2.

These scores are based on conventional expectations for a confounder that is itself a cause. That is, a potential confounder such as deposited sediment by itself can cause extirpation of invertebrate genera (independent combined action) or can act in combination with conductivity to extirpate invertebrate genera (additive or more than additive combined action). However, sometimes correlations are anomalous. For example, a confounder may actually decrease effects. Such anomalous results require case-specific interpretation, based on knowledge of mechanisms and characteristics of the ecosystems being analyzed.

Anomalous results may also result from violation of the expectation that a confounder should be correlated with both conductivity and the effect. If only one of the correlations is observed, that result requires additional interpretation. If the potential confounder is correlated with the effect, but not with conductivity, the result may be due to chance, or to a partitioning of causation in space. That is, they are independent, because the confounder impairs communities at different locations than conductivity. This could occur if the potential confounder and conductivity have different sources. In any case, it is not a confounder of conductivity.

In the contingency tables (Evidence Type 3), the frequency of occurrence of any Ephemeroptera (i.e., of the failure to extirpate all ephemeropteran genera) is presented for combinations of high and low levels of conductivity and of the potential confounder. If the frequency of occurrence is much lower when the confounder is present at high levels, this is supporting evidence for confounding. Note, the goal here is not to determine the effects of

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1 exceeding a criterion or other benchmark. Rather the goal is to clarify the co-occurrence of  
2 conductivity, confounders, and effects by determining the frequency of effects at each possible  
3 combination of extremely high and low levels of conductivity and the potential confounder. It is  
4 expected that, if a variable is indeed a confounder, its influence on the occurrence of effects  
5 would be seen at an extreme level. This use of contingency tables could reveal influences of  
6 confounders that are obscured when the entire ranges of data are correlated. Therefore, clearly  
7 high and low levels of conductivity and the potential confounder are used in contingency tables.

8 A potential confounder gets a plus score if its presence at a high level reduces the  
9 probability of occurrence by more than 25% and a minus score if it does not (see Table B-3). It  
10 gets a double plus score if its presence at a high level reduces the probability of occurrence by  
11 more than 75% and a double minus score if it raises it by less than 10%. Any decrease in effects  
12 at high levels of a potential confounder is anomalous and is treated as strong negative evidence.

13 The evidence concerning sufficiency of the confounder (Evidence Types 5–8) is diverse.  
14 Only Evidence Type 6 was sufficiently common and consistent to develop scoring criteria. For  
15 Evidence Type 6, the primary consideration is the degree of departure of the correlation in the  
16 truncated data set (regarding pH, RBP, and fecal coliform) from the correlation of conductivity  
17 and Ephemeroptera ( $r = 0.63$ ) in the full data set (see Table B-4).

18 For alteration, the primary consideration is the degree of specificity of the effects of the  
19 confounder relative to those of the salts. This type of evidence is rare and is scored ad hoc when  
20 it occurs.

21 Additional considerations that may result in a higher score are presented in Table B-5.

### 23 **B.3. WEIGHING**

24 After the individual pieces of evidence had been weighted, the body of evidence for a  
25 potential confounder was weighed based on the credibility, diversity, strength, and coherence of  
26 the body of evidence (see Table B-6). The body of evidence, rather than a single piece of  
27 evidence, was considered to determine how strongly these potential confounders might affect the  
28 model.

### 30 **B.4. POTENTIAL CONFOUNDERS**

#### 31 **B.4.1. Habitat Quality**

32 Stream habitat may be modified in reaches that receive high conductivity effluents.  
33 Habitat quality was represented by a qualitative index, the RBP derived by the WVDEP, which  
34 increases as habitat quality increases.

1 Although habitat scores were correlated with both conductivity and biological response,  
2 which indicates a potential for confounding, low RBP was judged to have little effect on the  
3 derivation of the 5<sup>th</sup> percentile hazardous concentration (HC<sub>05</sub>) for conductivity (see Table B-7  
4 and B-8).

#### 6 **B.4.2. Organic Enrichment**

7 Sources of organic enrichment such as domestic sewage and animal wastes are also  
8 sources of salts that contribute to conductivity. Fecal coliform counts are an indicator of organic  
9 enrichment and the presence of sources that may contain other toxicants such as household  
10 waste. The data show no indication of significant confounding associated with fecal coliform  
11 counts and effects attributed primarily to organic enrichment (see Tables B-9 and B-10).

#### 13 **B.4.3. Nutrients**

14 Nitrogen and phosphorus may also come from sewage and animal wastes or from  
15 fertilizers used in agriculture or mine reclamation. Because neither nutrient was correlated with  
16 conductivity or Ephemeroptera, effects could not be confounded by nutrients when conductivity  
17 increased (see Table B-11).

#### 19 **B.4.4. Deposited Sediment**

20 Sources of salts can be associated with erosion and silt that affect stream organisms. A  
21 qualitative measure of embeddedness was evaluated by correlation and by contingency table (see  
22 Table B-13). Embeddedness was judged to have little if any effect on the derivation of the HC<sub>05</sub>  
23 for conductivity (see Tables B-12 and B-13).

#### 25 **B.4.5. High pH**

26 The dissolution of limestone and dolomite increases as unweathered surface area of rock  
27 increases. Waters draining crushed limestone and dolomite contain HCO<sub>3</sub><sup>-</sup> which contributes to  
28 higher pH and alkalinity. The HCO<sub>3</sub><sup>-</sup> that raises pH is also a major anion moiety that contributes  
29 to conductivity. Hence, pH directly reflects a major constituent of conductivity (HCO<sub>3</sub><sup>-</sup>) and  
30 should not be analyzed as a potential confounder. In addition, salts influence hydrogen ion  
31 activity which is measured as pH. In any case, variance in pH was judged to have little effect on  
32 the derivation of the HC<sub>05</sub> for conductivity in waters above pH 7 (see Tables B-14 and B-15).

#### **B.4.6. Low pH**

Because low pH from acid mine drainage is known to be an important cause of impairment where it occurs, it was judged a priori to be a potentially important environmental variable. That preconception was supported by the evidence summarized here. Therefore, sites with pH <6 were not used to calculate the XC values. However, Table B-15 suggests that even below pH 4.5, conductivity is more important than acidity to the occurrence of Ephemeroptera (see Tables B-15 and B-16). So, although the benchmark applies to waters with neutral or basic pH, high conductivity appears to also cause effects at low pH.

#### **B.4.7. Selenium**

Selenium (Se) is a potential confounder because it is commonly associated with coal, and elevated levels have been reported in the region. In an analysis of a small data set, Pond et al. (2008a) found that the number of ephemeropteran genera was highly correlated with Se concentration ( $r = -0.88$ ,  $n = 20$ ). In contrast, weak correlations were found in our analysis of the West Virginia data. This result is unreliable, because most of the Se values were detection limits, and many of the detection limits were relatively high, equaling or exceeding the water quality criterion of 5.0 µg/L. In addition, there were too few high Se concentrations in the West Virginia data to perform a contingency table analysis. For these reasons, we did not include a quantitative analysis of potential confounding by Se. The effects of Se in central Appalachian streams should be investigated further.

#### **B.4.8. Temperature**

Elevated temperature may occur with elevated conductivity if the sources of salts are associated with lack of stream shading or if saline effluents are heated. Although temperature is moderately correlated with conductivity on an annual basis, the correlation is greatly reduced by seasonal partitioning (see Tables B-17 and B-18). More importantly, elevated temperature does not appear to be associated with the loss of Ephemeroptera.

#### **B.4.9. Lack of Headwaters**

The loss of headwaters due to mining and valley fill eliminates a source of recolonization for downstream reaches. Hypothetically, this could result in extirpation of invertebrates, if the sampled sites are sink habitats that must be recolonized by headwater source habitats. This is plausible in stream reaches immediately below valley fills. However, where there are other headwaters on tributaries above the sampling site, they serve as alternative sources for recolonization. No regional data are available to address this issue. However, examination of

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individual watersheds shows that many if not most of the sampled sites have at least one upstream intact headwater. Two examples are presented here.

Ballard Fork, a tributary to the Mud River in West Virginia, is downstream of several valley fills but has unmined tributaries upstream such as Spring Branch (see Figures B-2, B-3, B-4). Conductivity in Spring Branch measured <44–66  $\mu\text{S}/\text{cm}$ . Conductivity in Ballard Fork was 464–2,300  $\mu\text{S}/\text{cm}$ . In Spring Branch, the benthic invertebrate assemblages in the springs of 1999, 2000, and 2006 had 6–8 genera of Ephemeroptera representing 29–45% of the sample. In contrast, on the same dates Ballard Fork had 1–3 genera of Ephemeroptera representing only 2–4% of the sample and those may be indicative of immigrant specimens. Hence, even when a source of recolonization was available from Spring Branch, ephemeropteran genera were extirpated in Ballard Fork where conductivity was elevated. Other potential confounders are apparently not responsible for differences between the creeks, because biological quality is not related to habitat quality (embeddedness, total RBP habitat score, and pH). Data are from U.S. EPA Mountain Top Mining studies (Green et al., 2000; Pond et al., 2008a) (see Table B-19).

In the Twentymile Creek watershed, the most upstream catchment above river kilometer (RKm) 44 is a small headwater that is 99% forested. Between RKm 44 and 13, the tributary catchments are heavily mined with valley fills. Below RKm 25 to the mouth, benthic invertebrate assemblages are depauperate. Two catchments that enter Twentymile Creek near Rkm 17 and 14 are 100% forested with diverse benthic invertebrate assemblages. Nevertheless, at RKm 12, the benthic assemblage in Twentymile Creek remains depressed. Downstream from RKm 12, there are mixed mining and forest land uses. Near RKm 2 there are legacy mining and urban land uses (see Table B-20). WVSCI scores and numbers of EPT taxa were low when conductivity was high regardless of the condition of catchments that provided sources of benthic macroinvertebrates including salt-sensitive genera. Data are from WABbase.

In these two examples, the reduction in ephemeropteran genera or EPT is not caused by a lack of sources of recolonization from headwaters. This is not to say that recolonization is never an issue. The sources of salts in this region are primarily chronic and localized, so lack of recolonization is unlikely to confound their effects. However, if an episodic agent caused the loss of aquatic organisms (e.g., drought or forest treatment with insecticides), sources of recolonization could be important.

#### **B.4.10. Catchment Area**

Larger streams tend to have more moderate chemical properties than small streams because they receive waters from more sources than small streams, both natural and anthropogenic. Consequently, extreme values, in this case both low and high conductivity, tend

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1 to occur less frequently in large streams. One of the initial data filters for this analysis was to  
2 exclude streams larger than 155 km<sup>2</sup> (or 60 mi<sup>2</sup>). Small streams are numerically more abundant  
3 than large streams and the inclusion of large streams might introduce extraneous variance. This  
4 raises the issue whether stream size is a potential confounder and whether the results from small  
5 streams might be extrapolated to larger streams. That is, do the same effects of conductivity  
6 occur in larger streams as were found in the detailed analysis? We examined these issues by  
7 analyzing the influence of stream size (as catchment area) on the effects of conductivity.

8 Correlation of log conductivity with log catchment area is extremely low ( $r = 0.12$ ).  
9 Owing to the large number of sites ( $N = 1,750$ ), the regression is statistically significant, but it is  
10 almost negligible and accounts for less than 2% of the variability in conductivity. Nearly all  
11 reference sites, even those identified as Level II and Level III, had conductivities less than  
12 300  $\mu\text{S}/\text{cm}$ .

13 We categorized streams by catchment area into three groups: small catchments less than  
14 6 mi<sup>2</sup> (15.5 km<sup>2</sup>), medium catchments of 6 to 60 mi<sup>2</sup> (155 km<sup>2</sup>), and large catchments greater  
15 than 60 mi<sup>2</sup>. The number of Ephemeroptera (mayfly) taxa declines with increasing conductivity  
16 in all streams, independent of classification of catchment area ( $r = -0.62$ ).

17 We likewise categorized conductivity into three groups by defining low conductivity as  
18  $<200 \mu\text{S}/\text{cm}$ , and high conductivity as  $>1,500 \mu\text{S}/\text{cm}$  (see Table B-21). In all three stream size  
19 categories, if conductivity was  $<200 \mu\text{S}/\text{cm}$ , 99% or more of all streams had mayfly populations,  
20 but if conductivity was above 1,500  $\mu\text{S}/\text{cm}$ , only 50% or fewer streams had mayflies (see  
21 Table B-21). Evidence for confounding by catchment area is summarized in Table B-22; the  
22 evidence is uniformly negative and we conclude that catchment area has little or no effect on  
23 invertebrate response to conductivity.

## 24 25 **B.5. SUMMARY OF ACTIONS TAKEN TO ADDRESS POTENTIAL** 26 **CONFOUNDING**

27 Low pH is a potential confounder, but sites with pH  $<6$  were removed from the data set  
28 when calculating the benchmark value. The influence of Se could not be evaluated due to poor  
29 data and should be investigated. However, toxic levels of Se appear to be relatively uncommon.  
30 Other potential confounders were eliminated from consideration with some confidence. We do  
31 not argue that these variables have no influence, but their effects appear to be minimal given the  
32 inevitable variability in sites to which the benchmark would be applied.

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**Table B-1. Relationships between qualities of evidence and scores for weighing evidence**

Qualities of the evidence	Score, not to exceed three minus or three plus
Logical implications and relevance	+, 0
Strength	Increase score
Other qualities	Increase score

**Table B-2. Weighting co-occurrence using correlations for Approaches 1–2**

Assessment	Strength	Score
Absent	$r \leq 0.1$	– –
Weak	$0.1 < r < 0.25$	–
Moderate	$0.75 \geq r \geq 0.25$	+
High	$r > 0.75$	++

**Table B-3. Weighting co-occurrence for Evidence Type 3 using contingency tables**

Assessment	Strength	Score
High levels of a confounder should increase the probability that a site lacks Ephemeroptera at low conductivity, and low levels of the confounder should decrease the effect at high conductivities	Increased effect >25%	+ for co-occurrence
	Increased effect >75%	++ for co-occurrence and strength
	Increased effect <25%	– for co-occurrence
	Increased effect <10% or decreased effect	– – for co-occurrence and strength

**Table B-4. Weighting sufficiency for Evidence Type 6: alteration of the correlation of conductivity with the number of ephemeropteran genera after removal of elevated levels of a confounder**

Assessment	Strength	Score
Removal of elevated levels of a confounder should change the correlation coefficient	Coefficients deviating by <10% $0.56 < r < 0.69$	– – for a lack of change in effect with removal of confounder
	Coefficients deviating by <20% $0.50 \leq r \leq 0.75$	– for a small change in effect with removal of confounder
	Coefficients deviating by >20% $0.50 > r > 0.75$	+ for a strong increase or decrease in effect with removal of confounder

**Table B-5. Considerations used to weight the evidence concerning the influence of potentially confounding variables**

Quality of evidence	Descriptor
Logical implication	Negative or positive
Directness of cause	Proximate cause, sources, or intermediate causal connections
Specificity	Effect attributable to only one cause or to multiple causes
Relevance to effect	From the case or from other similar situations
Nature of the association	Quantitative or qualitative
Strength of association	Strong relationships and large range or weak relationships and small range
Consistency of information	All consistent or some inconsistencies
Quantity of information	Many data or few data
Quality of information	Good study or poor study

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**Table B-6. Weighing confidence in the body of evidence for a potential confounder**

<b>Assessment</b>	<b>Score</b>	<b>Body of evidence</b>	<b>Action</b>
Very confident	— — —	All minus, some strongly negative evidence	No treatment for confounding
Moderately confident	— —	All minus, no strongly negative evidence	No treatment for confounding
Reasonably confident	—	Majority minus	No treatment for confounding
Undetermined	0	Approximately equal positive and negative, ambiguous evidence, or low quality evidence	Additional study advised
Potential confounding	+	Majority plus	Correction for confounding may be advised

**Table B-7. Evidence and weight for confounding by habitat quality**

Approach	Score	Evidence
1. Correlation of cause and confounder	+	RBP score was moderately correlated with conductivity, ( $r = -0.29$ , $n = 2,344$ ).
2. Correlation of effect and confounder	+	RBP score was (barely) moderately correlated with the number of ephemeropteran genera ( $r = 0.26$ , $n = 2,193$ ).
3. Contingency of high level of cause and confounder	–	In a contingency table (see Table B-8), Ephemeroptera are present at >99% of sites with low conductivity (<200 $\mu\text{S}/\text{cm}$ ) even when habitat is poor (<115). However, with high conductivity, Ephemeroptera are present at only 40% of sites with poor habitat and 60% of sites with good habitat.
6. Removal of confounder	–	When sites with moderate to poor habitat (an RBP score <140) were removed from the analysis, conductivity is a little less negatively correlated with the number of Ephemeroptera ( $r = -0.50$ , $n = 768$ ) (see Table B-8).
		The SSD and $\text{HC}_{05}$ are very similar when the $\text{XC}_{95}$ values were calculated with a year-long data set and a subset of the data set with sites removed with pH of <6, RBP score <135, and fecal coliform >400 colonies/100 mL (see Figure B-1).
<b>Weight of evidence</b>	–	Somewhat confident, evidence is mixed, but the contingency table gives relatively strong negative evidence (Ephemeroptera occur even when habitat is poor), while RBP explains only 6.7% of the variance in ephemeropteran occurrence.

SSD = species sensitivity distribution.

**Table B-8. Number of sites with high and low quality habitat and high and low conductivity with Ephemeroptera present in streams (pH > 6)**

	Conductivity <200 $\mu$ S/cm	Conductivity $\geq$ 1,500 $\mu$ S/cm
Habitat score <115	155/157 (98.7%)	12/31 (39.7%)
Habitat score $\geq$ 140	388/390 (99.5%)	13/22 (59.1%)

**Table B-9. Evidence and weights for confounding by organic enrichment**

Approach	Score	Evidence
1. Correlation of cause and confounder	--	Fecal coliform counts were weakly correlated with conductivity ( $r = 0.25$ , $n = 2,044$ ).
2. Correlation of effect and confounder	--	Coliform count was not correlated with the number of ephemeropteran genera ( $r = -0.14$ , $n = 1,349$ ).
3. Contingency of high level of cause and confounder	--	In a contingency table (see Table B-10), the presence of high coliform counts did not change the probability of finding Ephemeroptera at either high or low conductivity (see Table B-10).
6. Removal of confounder	--	(a) When samples >400 colonies/100 mL were removed from the analysis, the correlation of conductivity with Ephemeroptera was unchanged ( $r = -0.63$ , $n = 1,671$ ). (b) The SSD and HC <sub>05</sub> are very similar when the XC <sub>95</sub> is calculated with a year-long data set and a subset of the data set with sites removed with pH of <6, RBP score <135, and fecal coliform >400 colonies/100 mL (see Figure B-1).
<b>Weight of evidence</b>	--	Very confident: All negative, some strongly negative. No treatment for confounding.

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**Table B-10. Number of sites with high and low conductivity with high and low levels of fecal coliform with Ephemeroptera present in streams**

	Conductivity <200 $\mu$ S/cm	Conductivity $\geq$ 1,500 $\mu$ S/cm
Coliform <400 colonies/100 mL	658/662 (99.4%)	36/77 (46.7%)
Coliform >400 colonies/100 mL	233/237 (98.3%)	20/42 (47.6%)

**Table B-11. Evidence and weights for confounding by nutrients**

Approach	Score	Evidence
1. Correlation of cause and confounder	--	Conductivity was not correlated with nitrate and nitrite ( $r = 0.08$ , $n = 1,265$ ) or total phosphorus ( $r = 0.05$ , $n = 1,190$ ).
2. Correlation of effect and confounder	--	Ephemeroptera was not correlated with nitrate and nitrite ( $r = 0.037$ , $n = 1,184$ ) or total phosphorous ( $r = 0.001$ , $n = 1,186$ ).
3. Contingency of high level of cause and confounder	NA	Contingency table analyses were not used because extreme nutrient levels were rare at high conductivities.
6. Removal of confounder	--	When samples with nitrate plus nitrite >0.6 mg/L were removed from the analysis, the correlation of conductivity with the number of Ephemeroptera was similar ( $r = -0.54$ , $n = 999$ ). When samples with total phosphorus >0.04 mg/L were removed from the analysis, the correlation of conductivity with the number of Ephemeroptera was similar ( $r = -0.56$ , $n = 999$ ).
<b>Weight of evidence</b>	--	Moderately confident: all negative, none strongly negative. No treatment for confounding.

NA = not applicable.

**Table B-12. Evidence and weights for confounding by deposited sediment**

Approach	Score	Evidence
1. Correlation of cause and confounder	--	The WABbase embeddedness score is weakly correlated with conductivity ( $r = -0.18$ , $n = 2,202$ ).
2. Correlation of effect and confounder	--	The WABbase embeddedness score is weakly correlated with Ephemeroptera ( $r = -0.22$ , $n = 2,198$ ).
3. Contingency of high level of cause and confounder	--	In a contingency table (see Table B-13), high embeddedness (score >15) has little effect at either high or low conductivity (see Table B-13).
6. Removal of confounder	--	When samples with an embeddedness score <13 are removed from the analysis, the correlation of conductivity with the number of Ephemeroptera was virtually unchanged ( $r = -0.61$ , $n = 1,089$ ).
<b>Weight of evidence</b>	--	Very confident: all negative, some strongly. No treatment for confounding.

**Table B-13. Number of sites with high and low embeddedness scores and high and low conductivity with Ephemeroptera present in streams (pH >6)**

	Conductivity <200 $\mu\text{S}/\text{cm}$	Conductivity >1,500 $\mu\text{S}/\text{cm}$
Embeddedness score <7	56/58 (96.6%)	7/16 (43.8%)
Embeddedness score >15	208/225 (92.4%)	6/15 (40%)

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**Table B-14. Evidence and weights for confounding by high pH**

<b>Approach</b>	<b>Score</b>	<b>Evidence</b>
1. Correlation of cause and confounder	+	Conductivity was moderately correlated with pH between 7 and 9.0, ( $r = 0.45$ , $n = 1,911$ ).
2. Correlation of effect and confounder	--	High pH was weakly correlated with Ephemeroptera ( $r = 0.19$ , $n = 1,907$ ).
3. Contingency of high level of cause and confounder	0	In a contingency table (see Table B-15), there were too few streams with high pH to provide evidence for or against confounding.
5. Levels of confounder is known to cause effects	-	U.S. EPA (1976) Water Quality Standards indicate that water quality 6.5–9 is protective of freshwater fish.
6. Removal of confounder shows it is important	--	When samples with pH > 8.5 are removed from the analysis, the correlation of conductivity with the number of Ephemeroptera was unchanged ( $r = -0.63$ , $n = 1,089$ ) (see Table B-15).
8. Potential confounding evaluated by frequency	-	The number of sites with a pH >8.5 is a very small proportion of the sample (<2.5%).
<b>Weight of evidence</b>	-	Reasonably confident: majority negative. No treatment for confounding.

**Table B-15. Number of sites with high and low conductivity with high and low levels of pH with Ephemeroptera present**

	<b>Conductivity &lt;200 <math>\mu\text{S}/\text{cm}</math></b>	<b>Conductivity <math>\geq 1,500 \mu\text{S}/\text{cm}</math></b>
pH <4.5	16/19 (84.2%)	0/14 (0%)
pH >8.5	3/3 (100%)	4/8 (50%)

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**Table B-16. Evidence and weights for confounding by low pH**

<b>Approach</b>	<b>Score</b>	<b>Evidence</b>
1. Correlation of cause and confounder	+	Conductivity was moderately correlated with pH <6 ( $r = 0.48$ , $n = 145$ ).
2. Correlation of effect and confounder	+	Low pH was moderately correlated with Ephemeroptera ( $r = 0.46$ , $n = 145$ ).
3. Contingency of high level of cause and confounder	–	Even at low pH some low conductivity streams support some Ephemeroptera but not at high conductivities (see Table B-15).
<b>Weight of evidence</b>	+	Potential confounding: majority positive. Correction for confounding may be advisable.

**Table B-17. Evidence and weights for confounding by temperature**

Approach	Score	Evidence
1. Correlation of cause and confounder	0	Conductivity was moderately correlated with year-round temperature, $r = 0.39$ , $n = 2,221$ . When the correlation was recalculated for the spring and summer index periods, conductivity was less correlated, but still moderately, with the summer ( $r = 0.29$ , $n = 961$ ). Spring temperatures, however, were weakly correlated with conductivity ( $r = 0.16$ , $n = 1,199$ ).
2. Correlation of effect and confounder	–	Temperature was weakly correlated with Ephemeroptera year round ( $r = -0.196$ , $n = 2,363$ ) and in summer ( $r = -0.12$ , $n = 961$ ) and not correlated in spring ( $r = -0.04$ , $n = 1,195$ ).
3. Contingency of high level of cause and confounder	– – –	Ephemeroptera were present at >98–100% of sites at low conductivity at both high and low temperature. In the high conductivity categories, Ephemeroptera occurred in more sites with elevated temperatures (see Table B-18), which is contrary to expectations, if temperature were contributing to the impairment.
5. Levels of confounder is known to cause effects	–	Temperatures rarely exceeded 20°C and, therefore, are not likely to cause extirpation of genera.
6. Removal of confounder shows it is important	– –	When high temperatures (>22°C) were deleted, the correlation of conductivity and Ephemeroptera was barely changed ( $r = -0.61$ , $n = 1,788$ ).
<b>Weight of evidence</b>	– – –	Moderately confident: all negative, some strongly negative. No treatment for confounding.

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**Table B-18. Number of sites with high and low temperatures and high and low conductivity with Ephemeroptera present in streams (pH >6)**

	Conductivity <200 µS/cm	Conductivity >1,500 µS/cm
Temperature <17°C	468/474 (98.7%)	9/27 (33.3%)
Temperature >22°C	78/78 (100%)	24/43 (55.8%)

**Table B-19. Comparison of low conductivity Spring Branch with high conductivity Ballard Fork**

Stream Name	Date	Embd.	Total RBP Score	pH	µS/cm	# E	% E	Total Count
Spring Branch	5/9/2006	16	149	7.7	66	8	29.27	205
Spring Branch	4/18/2000	16	163	7.5	44	6	44.76	143
Spring Branch	4/20/1999			7.7	51	8	34.72	337
Ballard Fork	5/9/2006	14	149	8.1	1,195	3	2.96	203
Ballard Fork	4/18/2000	12	148	7.1	464	1	2.08	48
Ballard Fork	1/25/2000			7.9	1,050	0	0	52
Ballard Fork	7/26/1999			8.2	2,300	0	0	88
Ballard Fork	4/20/1999			8.1	1,201	3	4.12	291

Embd. = embeddedness score from RBP; RBP = Rapid Bioassessment Protocol Habitat Evaluation; # E = Number of ephemeroptera genera; % E = percent of ephemeroptera individuals in the sample; Total count = count of all individuals of all taxa.

**Table B-20. Twentymile Creek sampling locations, conductivity, habitat score, number of EPT taxa, and WVSCI scores**

Year	River Kilometer	Tributary Catchment Land Use <sup>a</sup>	Max Reported Conductivity (μS/cm)	RBP Habitat Score	# EPT Taxa	WVSCI
2003	44.6	Forested	44	148	6	90.72
2004	44.6	Forested	37			-
1998	25.1	Mined	805	155	3	67.62
2003	25.1	Mined	2,087	153	1	58.45
2003	11.9	Mixed Forest and Mine	1,702	157	2	64.74
2004	11.9	Mixed Forest and Mine	1,282	-	-	-
2003	1.8	Mixed Forest, Mine, & Urban	987	-	-	-
2004	1.8	Mixed Forest, Mine, & Urban	1,138	-	-	-
2003	0.5	Mixed Forest, Mine, & Urban	845	146	3	66.73
2004	0.5	Mixed Forest, Mine, & Urban	836	-	-	-
1998	0	Mixed Forest, Mine, & Urban	590	131	3	65.94

<sup>a</sup>Land use refers to catchment land use of tributaries upstream from the sampled sites in Twentymile Creek.

# EPT taxa = Number of Ephemeroptera, Plecoptera, and Trichoptera taxa; WVSCI = West Virginia Stream Condition Index.

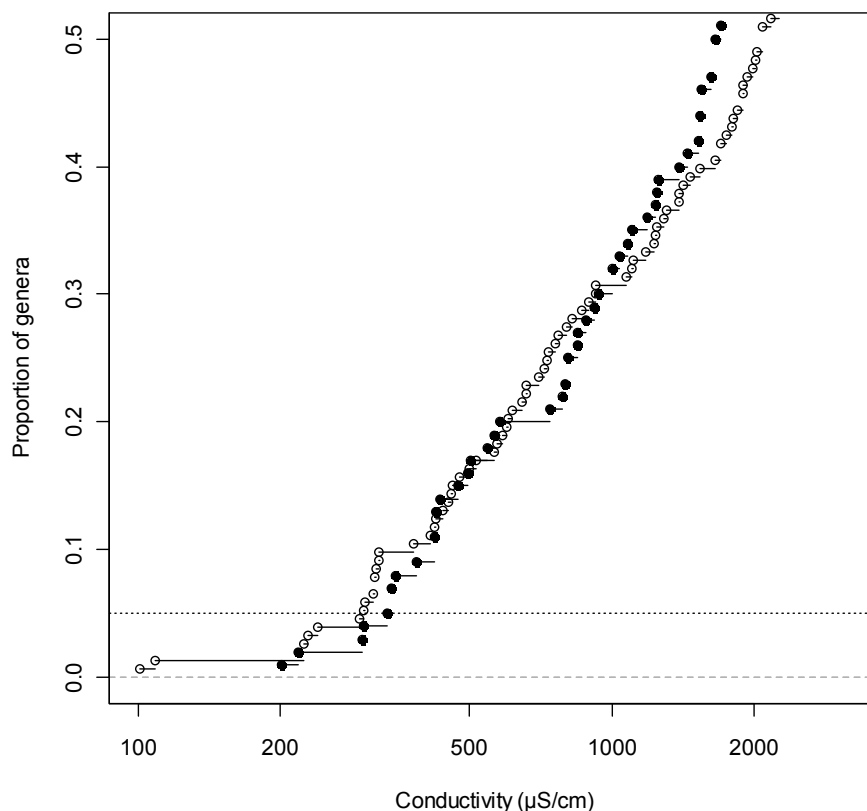
**Table B-21. Number (and percent) of streams with Ephemeroptera present: small, medium and large streams and low, medium and high conductivity (pH > 6).**

	Conductivity < 200 μS/cm	Conductivity > 1,500 μS/cm
Small streams	426/430 (99%)	16/39 (41%)
Medium streams	205/207 (99%)	19/38 (50%)
Large streams	70/70 (100%)	1/2 (50%)

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**Table B-22. Evidence and weights for confounding by catchment area**

<b>Approach</b>	<b>Score</b>	<b>Evidence</b>
1. Correlation of cause and confounder	--	Log catchment area was very weakly correlated with log conductivity ( $r = 0.12$ , $n = 1,750$ ).
2. Correlation of effect and confounder	---	Log catchment area was not correlated with the number of ephemeropteran genera ( $r = 0.05$ , $n = 1,750$ ).
3. Contingency of high level of cause and confounder	---	In a contingency table (see Table B-21), large catchment area did not change the probability of finding Ephemeroptera at either high or low conductivity.
6. Removal of confounder	--	Overall correlation of conductivity with Ephemeroptera in all sites was $r = -0.62$ , $n = 1,750$ ). When correlation was repeated for each of the size classes, the correlations were $-0.48$ (large streams; $n = 165$ ), and $-0.64$ (small and medium streams; $n = 942$ and $653$ ).
<b>Weight of evidence</b>	---	Very confident: All negative, some strongly negative. No treatment for confounding.



**Figure B-1. Species sensitivity distribution for all year, pH >6 and all sites (open circles) and for sites with pH  $\geq 6$ , Rapid Bioassessment Protocol  $\geq 135$  and fecal coliform  $\leq 400$  colonies/100 mL (closed circles).** Habitat disturbance and organic enrichment have little influence; the HC<sub>05</sub> for the constrained data set is 300  $\mu\text{S/cm}$  based on 111 genera. The upper and lower confidence bounds on that value are 225  $\mu\text{S/cm}$  and 350  $\mu\text{S/cm}$ , respectively.

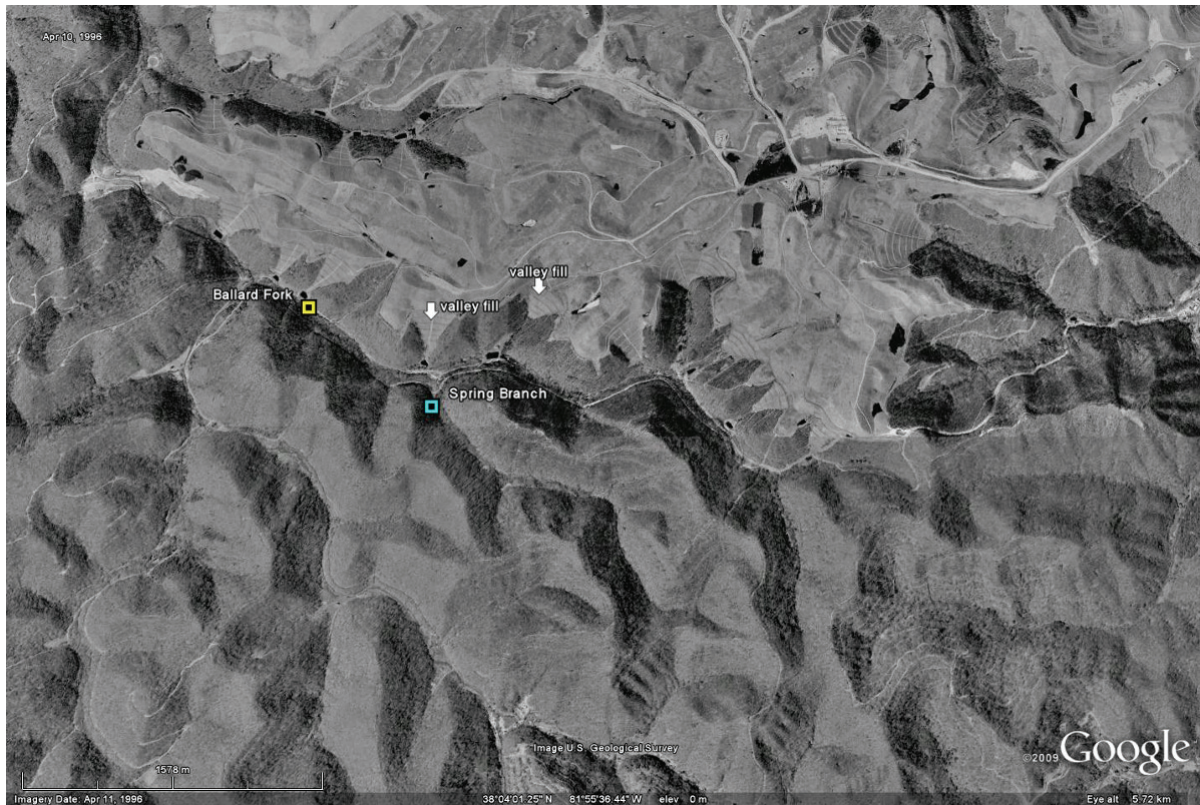






**Figure B-3. Aerial imagery (June 13, 2007) with superimposed sampling locations of Spring Branch (turquoise square) and Ballard Fork (yellow square). Mined land drains into Ballard Fork (upper section of image) and forested land drains into Spring Branch (lower right quadrant). Two valley fills indicated as examples.**





**Figure B-4. Same area as Figure 2.** Aerial imagery (April 10, 1996) with superimposed sampling locations of spring branch (turquoise square) and Ballard Fork (yellow square). The many upstream valley fills in Ballard Fork are easily seen.

**APPENDIX C**  
**EXTIRPATION CONCENTRATION VALUES FOR INVERTEBRATES**

	Genus	Both			Spring		Summer	
		XC <sub>95</sub>	N	Ref.	XC <sub>95</sub>	N	XC <sub>95</sub>	N
1	Ablabesmyia	>11,646	162	5	3,162	56	11,646	106
2	Acentrella	1,289	748	31	1,289	422	769	326
3	Acroneuria	2,630	480	60	1,649	138	2,320	342
4	Alloperla	228	96	15	319	82		
5	Ameletus	599	192	30	388	189		
6	Amphinemura	805	561	42	1,468	556		
7	Antocha	>6,468	538	18	3,725	162	6,468	376
8	Argia	9,790	75	NA			9,790	71
9	Asellus	925	33	2				
10	Atherix	>11,646	156	3			11,646	149
11	Atrichopogon	2,257	42	3			2,257	40
12	Attenella	574	34	1				
13	Baetis	1,383	1,509	72	1,383	642	1,494	867
14	Baetisca	918	47	NA			646	32
15	Bezzia	381	62	2	563	39	11,227	127
16	Bezzia/Palpomyia	4,713	306	26	3,725	179		
17	Boyeria	>7,340	173	5	1,468	52	7,340	121
18	Brillia	1,746	91	6	1,083	51	2,768	40
19	Caecidotea	>4,713	137	1	1,083	51	4,713	62
20	Caenis	3,884	541	8	1,175	168	3,884	373
21	Calopteryx	3,489	52	NA			3,489	45
22	Cambarus	1,228	464	44	1,649	289	1,340	175
23	Cardiocladius	>2,257	185	2	1,530	86	2,257	99
24	Centropilum	1,075	90	6	1,175	59	1,075	31
25	Ceratopsyche	>6,468	885	29	3,314	232	6,468	653
26	Chaetocladius	>5,057	182	4	1,650	76	5,057	106
27	Chelifera	>3,341	152	9	1,650	64	3,341	88
28	Cheumatopsyche	>9,180	1,612	57	2,493	562	9,180	1,050
29	Chimarra	>3,972	490	11	1,175	100	3,972	390
30	Chironomus	>11,646	105	1	5,120	48	11,646	57
31	Chrysops	>11,646	76	1			11,646	51

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	Genus	Both			Spring		Summer	
		XC <sub>95</sub>	N	Ref.	XC <sub>95</sub>	N	XC <sub>95</sub>	N
32	Cinygmula	224	81	17	347	80		
33	Cladotanytarsus	>11,646	103	5	3,162	57	11,646	46
34	Clinocera	>4,713	60	6	1,573	33		
35	Conchapelopia	518	135	7	1,175	120		
36	Corbicula	9,790	184	NA	1,175	51	9,790	133
37	Cordulegaster	1,468	42	3				
38	Corydalis	>11,227	311	1	1,117	49	11,227	262
39	Corynoneura	2,006	149	5	1,650	82	2,768	67
40	Crangonyx	2,169	105	7	796	65	2,169	40
41	Cricotopus	>11,227	605	24	3,725	274	11,227	331
42	Cricotopus/Orthocladius	>6,468	1,054	13	3,725	493	7,340	561
43	Cryptochironomus	>3,489	287	3	3,162	129	3,489	158
44	Dasyhelea	>3,341	66	3			3,341	51
45	Demicryptochironomus	322	81	6	322	67		
46	Diamesa	>4,713	457	14	3,725	294	5,057	163
47	Dicranota	>7,010	327	43	1,649	160	7,010	167
48	Dicrotendipes	>11,646	192	1	3,314	79	11,646	113
49	Dineutus	9,790	46	NA				
50	Diphetor	648	134	17	653	88	701	46
51	Diplectrona	2,523	594	60	3,725	233	2,523	361
52	Diploperla	318	99	2	357	96		
53	Dixa	722	68	16	1,650	34	794	34
54	Dolophilodes	864	339	46	1,323	145	618	194
55	Drunella	294	172	18	660	153		
56	Dubiraphia	>7,370	141	3	3,162	33	7,370	108
57	Eccopectura	462	65	6	518	43		
58	Ectopria	1,386	311	32	1,175	121	1,570	190
59	Epeorus	316	359	57	500	280	247	79
60	Ephemera	736	138	20	1,175	45	627	93
61	Ephemerella	302	362	38	434	347		
62	Eukiefferiella	1,930	501	28	1,649	271	1,979	230
63	Eurylophella	476	173	19	280	98	554	75

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	Genus	Both			Spring		Summer	
		XC <sub>95</sub>	N	Ref.	XC <sub>95</sub>	N	XC <sub>95</sub>	N
64	Ferrissia	4,884	91	NA			4,884	80
65	Fossaria	5,057	30	NA				
66	Gammarus	>4,713	215	10	1,800	67	4,713	148
67	Glossosoma	1,650	154	7	1,650	38	925	116
68	Haploperla	423	235	27	497	182	603	53
69	Heleniella	1,700	62	7			2,768	35
70	Helichus	>11,646	328	18	1,650	164	11,646	164
71	Hemerodromia	>9,790	607	8	3,725	109	9,790	498
72	Heptagenia	313	68	3	269	55		
73	Hexatoma	>9,790	818	65	1,059	393	9,790	425
74	Hydroporus	822	32	1	810	30		
75	Hydropsyche	>7,010	981	21	3,725	234	7,010	747
76	Hydroptila	>11,646	278	4	3,162	51	11,227	227
77	Isonychia	1,177	712	16	1,175	234	1,068	478
78	Isoperla	459	485	39	694	428	704	57
79	Krenopelopia	2,320	61	2			2,320	36
80	Lanthus	2,087	66	7	1,175	34	1,702	32
81	Larsia	2,630	96	3	1,289	76		
82	Lepidostoma	109	88	12	796	74		
83	Leptophlebia	224	85	8	805	70		
84	Leucrocuta	425	219	29	1,175	158	418	61
85	Leuctra	2,087	1,170	84	1,175	665	2,257	505
86	Limnophila	2,768	49	10	322	33		
87	Limnophyes	>5,120	88	1	5,120	31	1,979	57
88	Limonia	>5,057	62	1			5,057	57
89	Lirceus	1,303	70	6	517	51		
90	Maccaffertium	1,111	174	13	680	82	1,177	92
91	Macronychus	1,890	39	4				
92	Microcylloepus	3,341	94	2			3,341	82
93	Micropsectra	>6,468	220	25	5,120	107	6,468	113
94	Microtendipes	>3,489	507	34	1,383	198	3,489	309
95	Microvelia	2,523	46	3			2,523	32

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	Genus	Both			Spring		Summer	
		XC <sub>95</sub>	N	Ref.	XC <sub>95</sub>	N	XC <sub>95</sub>	N
96	Nanocladius	1,485	50	NA				
97	Natarsia	1,842	54	1			1,842	36
98	Neophylax	323	122	36	578	116		
99	Nigronia	>9,790	726	37	3,162	204	7,340	522
100	Nilotanytus	2,630	112	3	731	49	2,630	63
101	Nixe	316	77	3	357	73		
102	Ochrotrichia	2,791	32	1				
103	Optioservus	9,790	1,429	65	1,890	500	7,370	929
104	Orconectes	3,162	205	2	3,162	56	1,978	149
105	Orthocladius	3,341	272	10	805	117	3,341	155
106	Oulimnius	2,791	219	27	1,650	73	2,440	146
107	Pagastia	1,800	46	2				
108	Palpomyia	1,870	40	NA				
109	Parachaetocladius	1,239	151	27	509	33	1,205	118
110	Paragnetina	2,087	39	3				
111	Parakiefferiella	1,700	75	2	1,006	39	1,896	36
112	Paraleptophlebia	439	432	46	496	295	488	137
113	Parametriocnemus	>4,713	1,450	72	2,493	687	4,713	763
114	Paraphaenocladius	>6,468	71	2			6,468	46
115	Paratanytarsus	>3,489	108	2	3,314	48	3,489	60
116	Paratendipes	11,227	78	NA	1,800	34	11,227	44
117	Peltoperla	659	124	12	1,650	73	745	51
118	Perlesta	3,314	314	8	3,162	289		
119	Phaenopsectra	2,332	89	2			2,332	64
120	Physella	>9,790	143	1	1,276	61	9,790	82
121	Pisidium	1,795	34	2				
122	Plauditus	927	286	12	847	209	2,257	77
123	Polycentropus	4,713	357	41	1,443	154	2,768	203
124	Polypedilum	>4,884	1,604	75	1,890	686	5,057	918
125	Potthastia	1,896	60	1	1,534	33		
126	Procladius	701	78	3	347	31	524	47
127	Promoresia	589	78	5			467	53

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	Genus	Both			Spring		Summer	
		XC <sub>95</sub>	N	Ref.	XC <sub>95</sub>	N	XC <sub>95</sub>	N
128	Prosimulium	565	89	21	808	82		
129	Prostoma	2,553	41	NA				
130	Psephenus	>9,790	853	36	1,479	329	2,553	39
131	Pseudochironomus	>11,646	31	2			7,370	524
132	Pseudolimnophila	1,418	130	11	731	78	1,740	52
133	Psychomyia	1,106	38	3			1,106	33
134	Pteronarcys	660	105	25	499	41	907	64
135	Pycnopsyche	299	40	10	502	31		
136	Remenus	101	35	3	183	35		
137	Rhagovelia	2,030	51	3				
138	Rheocricotopus	3,489	556	11	1,346	225	3,489	331
139	Rheopelopia	1,247	125	4	1,534	37	1,014	88
140	Rheotanytarsus	>3,489	938	28	1,346	252	3,489	686
141	Rhyacophila	1,890	379	58	1,650	225	5,057	154
142	Serratella	500	46	2				
143	Sialis	>11,227	261	3	3,725	52	11,227	209
144	Simulium	>6,468	1,084	26	1,800	408	6,468	676
145	Sphaerium	>9,790	39	NA				
146	Stempellina	617	33	8				
147	Stempellinella	892	304	26	562	120	1,075	184
148	Stenacron	769	249	15	316	105	850	144
149	Stenelmis	>9,790	1,217	27	3,162	539	9,790	678
150	Stenochironomus	1,613	40	NA				
151	Stenonema	729	905	61	875	331	687	574
152	Stictochironomus	3,162	39	NA				
153	Stylogomphus	>6,468	117	1			6,468	99
154	Sublettea	2,440	179	2	929	43	2,087	136
155	Sweltsa	761	294	43	1,650	126	777	168
156	Tabanus	>9,790	60	1	3,162	35		
157	Tallaperla	452	87	16			302	63
158	Tanytarsus	9,180	1,194	64	1,650	481	9,180	713
159	Thienemanniella	>9,790	389	9	2,493	203	9,790	186

*This document is a draft for review purposes only and does not constitute Agency policy.*

	Genus	Both			Spring		Summer	
		XC <sub>95</sub>	N	Ref.	XC <sub>95</sub>	N	XC <sub>95</sub>	N
160	Thienemannimyia	>6,468	1,326	56	1,649	536	6,468	790
161	Tipula	1,979	590	36	1,649	320	2,169	270
162	Tokunagaia	1,070	43	NA			1,070	35
163	Tribelos	2,257	45	NA				
164	Tricorythodes	2,006	44	NA			2,006	43
165	Tvetenia	>2,768	727	40	1,649	370	5,057	357
166	Utaperla	240	47	2			198	32
167	Wormaldia	1,533	73	8	796	31	1,746	42
168	Yugus	603	72	12	796	48		
169	Zavrelia	413	81	6	347	60		
170	Zavrelimyia	>2,768	240	11	834	112	4,884	128

Empty cells indicates fewer than 30 occurrences during that season.

XC<sub>95</sub> = 95<sup>th</sup> percentile extirpation concentration reported as  $\mu\text{S/cm}$ ; NA = not applicable because it never occurs at WVDEP reference locations; Both = March through October; Spring = Sampled March through June; Summer = July through October; Ref. = number of times the genus was observed at a reference site.



**APPENDIX D**  
**GRAPHS OF OBSERVATION PROBABILITIES AND CUMULATIVE DISTRIBUTION**  
**FUNCTIONS FOR EACH GENUS**

The purpose of Appendix D is to help the reader visualize the changes in the occurrence of each genus as conductivity increases. Figure D-1 contains general additive models of the relationship between capture probability of the genus and conductivity, ordered from the lowest to the highest  $XC_{95}$  value. Open circles are the probabilities of observing the genus within a range of conductivities. Circles at zero probability indicate no individuals at any sites were found at these conductivities. The line fitted to the probabilities is for visualization. The vertical red line indicates the  $XC_{95}$ . Note that different genera respond differently to increasing salinity. For example, *Lepidostoma* declines, *Diploperla* has an optimum, and *Cheumatopsyche* increases. The  $XC_{95}$  for genera like *Cheumatopsyche* are reported as “greater than” because extirpation did not occur in the measured range.

Figure D-2 contains the weighted cumulative distribution function (CDF) and the associated 95<sup>th</sup> percentile extirpation concentration value arranged in alphabetical order by genus. Each point shows the weighted proportion of samples with each genus present at (F(x)) the conductivity less than the indicated conductivity value ( $\mu\text{S}/\text{cm}$ ). The conductivity at the 95<sup>th</sup> percentile is the  $XC_{95}$  (arrow). The CDF was calculated from observations from March through October (all year; black connected points) from March through June (spring; green connected points), and from July through October (summer; red connected points). As there were fewer than 30 observations such as for *Drunella* between July and October, no CDF was developed for the summer index period. In a CDF, genera that are affected by increasing conductivity (e.g., *Drunella*) show a steep slope and asymptote well below the measured range of exposures, whereas genera unaffected by increasing conductivity (e.g., *Nigronia*) have a steady increase over the entire range of measured exposure and do not reach a perceptible asymptote.

## Capture Probability and Relative Abundance Along Conductivity Gradient

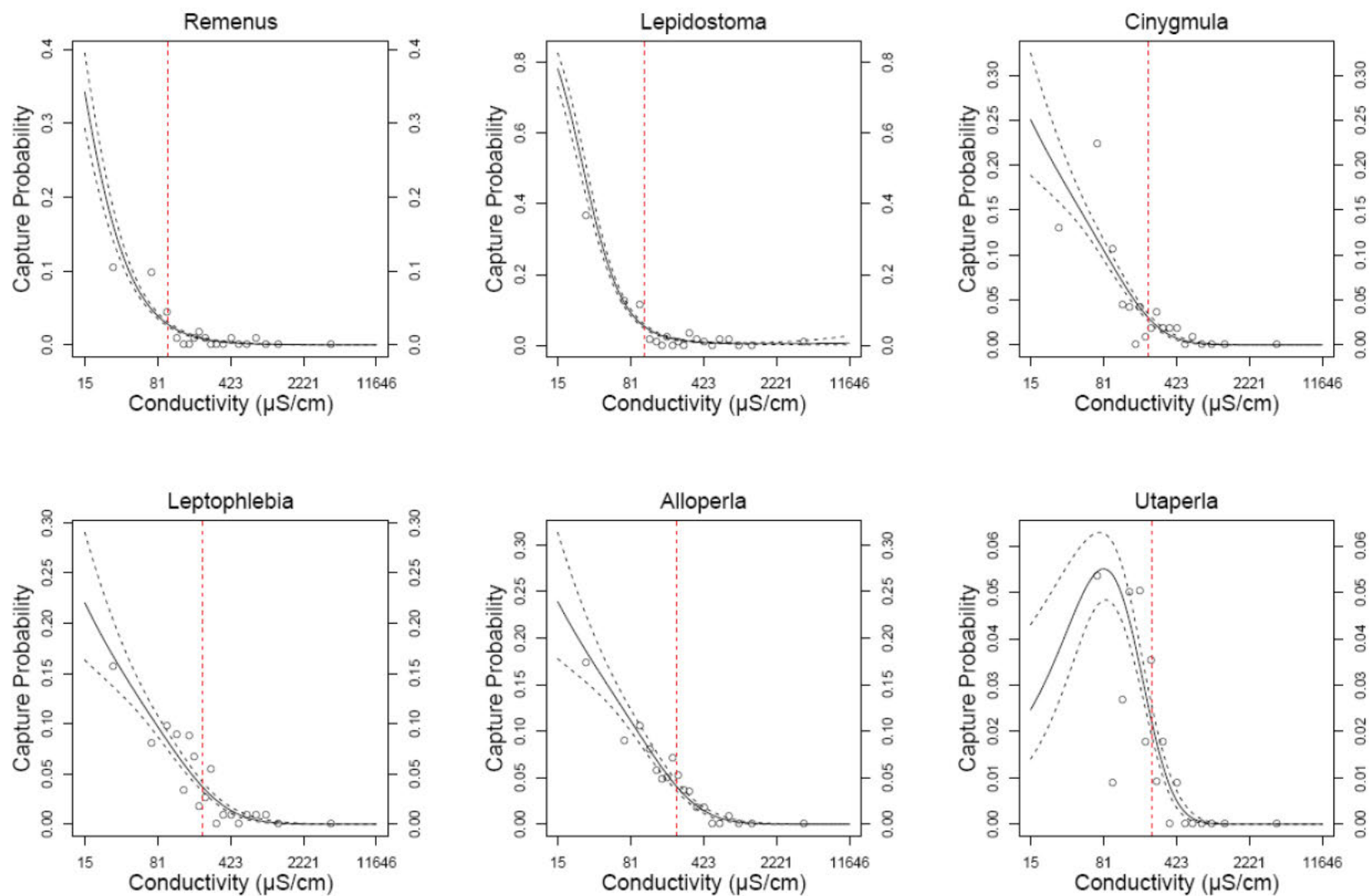


Figure D-1. Observation probabilities for each genus. Sites with pH < 6 excluded.

# Capture Probability and Relative Abundance Along Conductivity Gradient

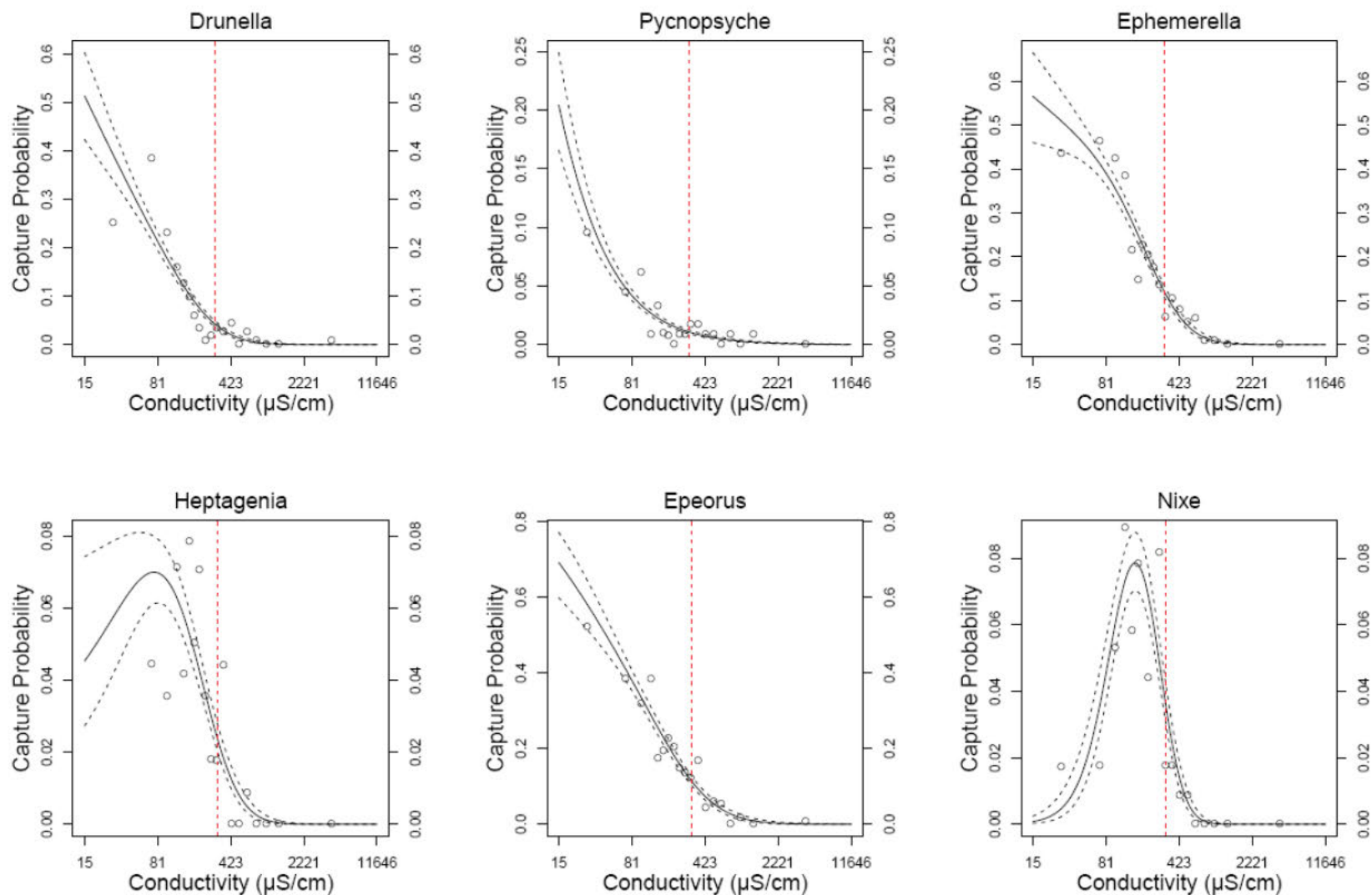


Figure D-1. Observation probabilities for each genus (continued).

## Capture Probability and Relative Abundance Along Conductivity Gradient

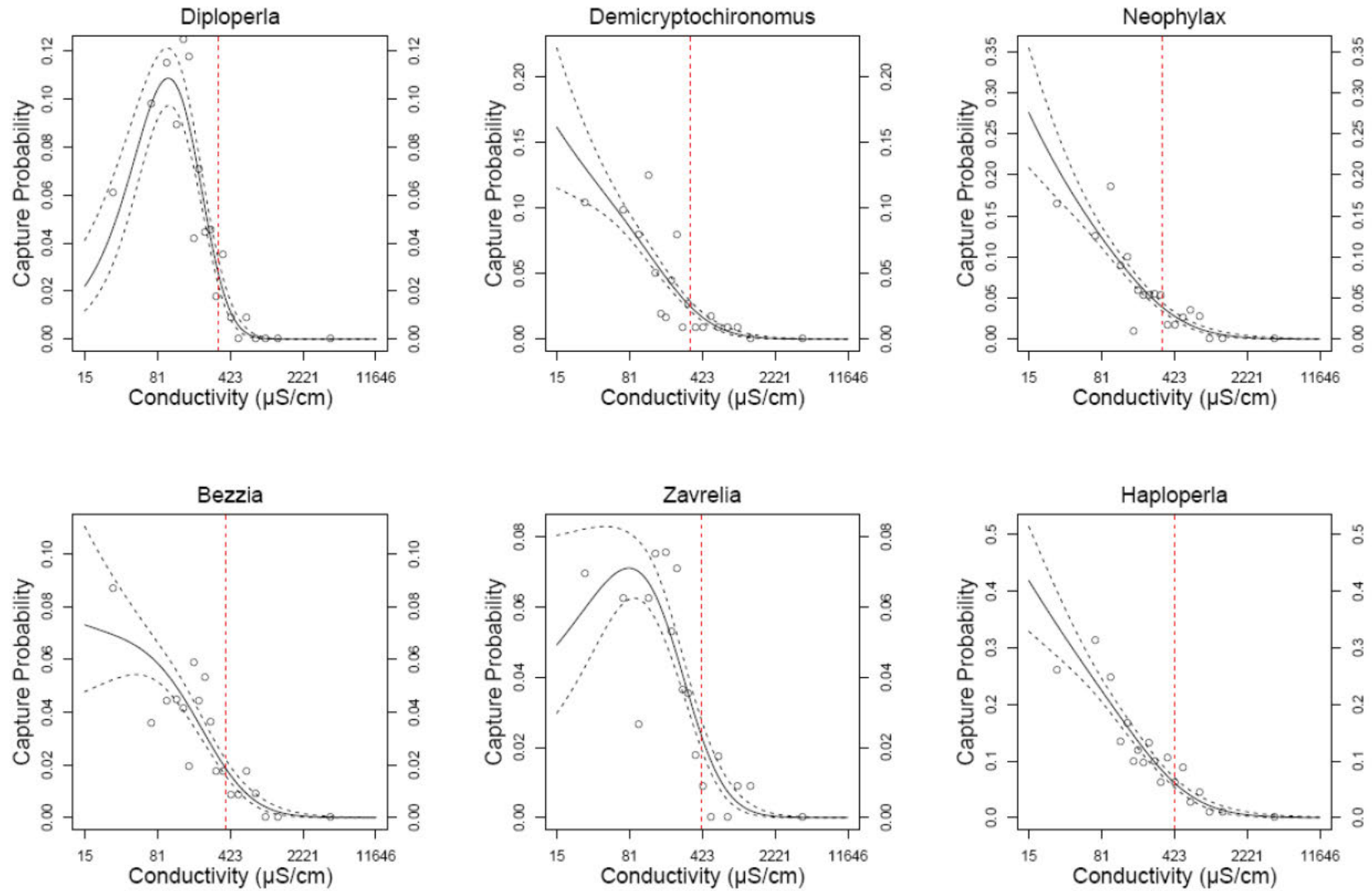
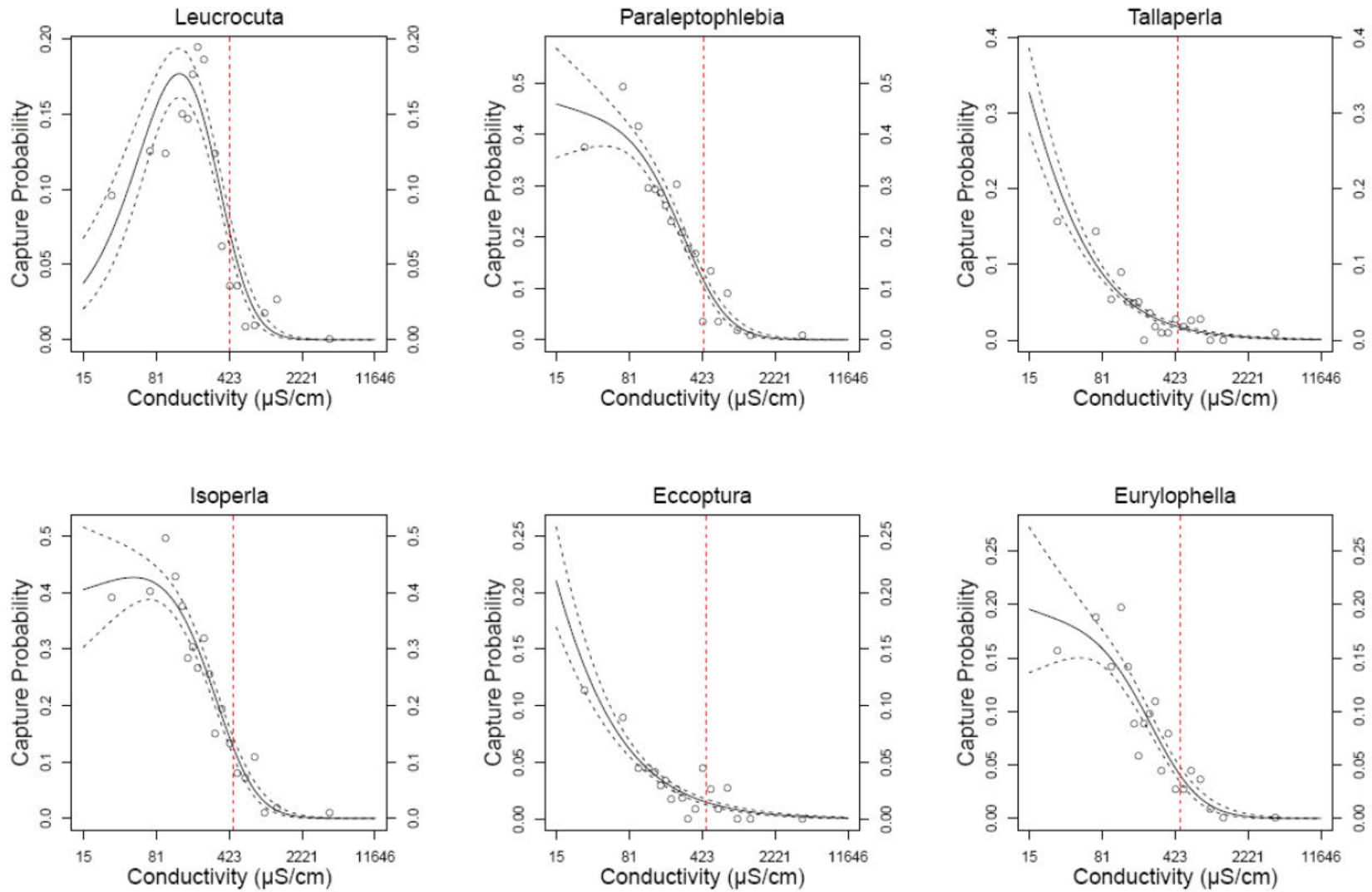


Figure D-1. Observation probabilities for each genus (continued).

# Capture Probability and Relative Abundance Along Conductivity Gradient



**Figure D-1. Observation probabilities for each genus (continued).**



## Capture Probability and Relative Abundance Along Conductivity Gradient

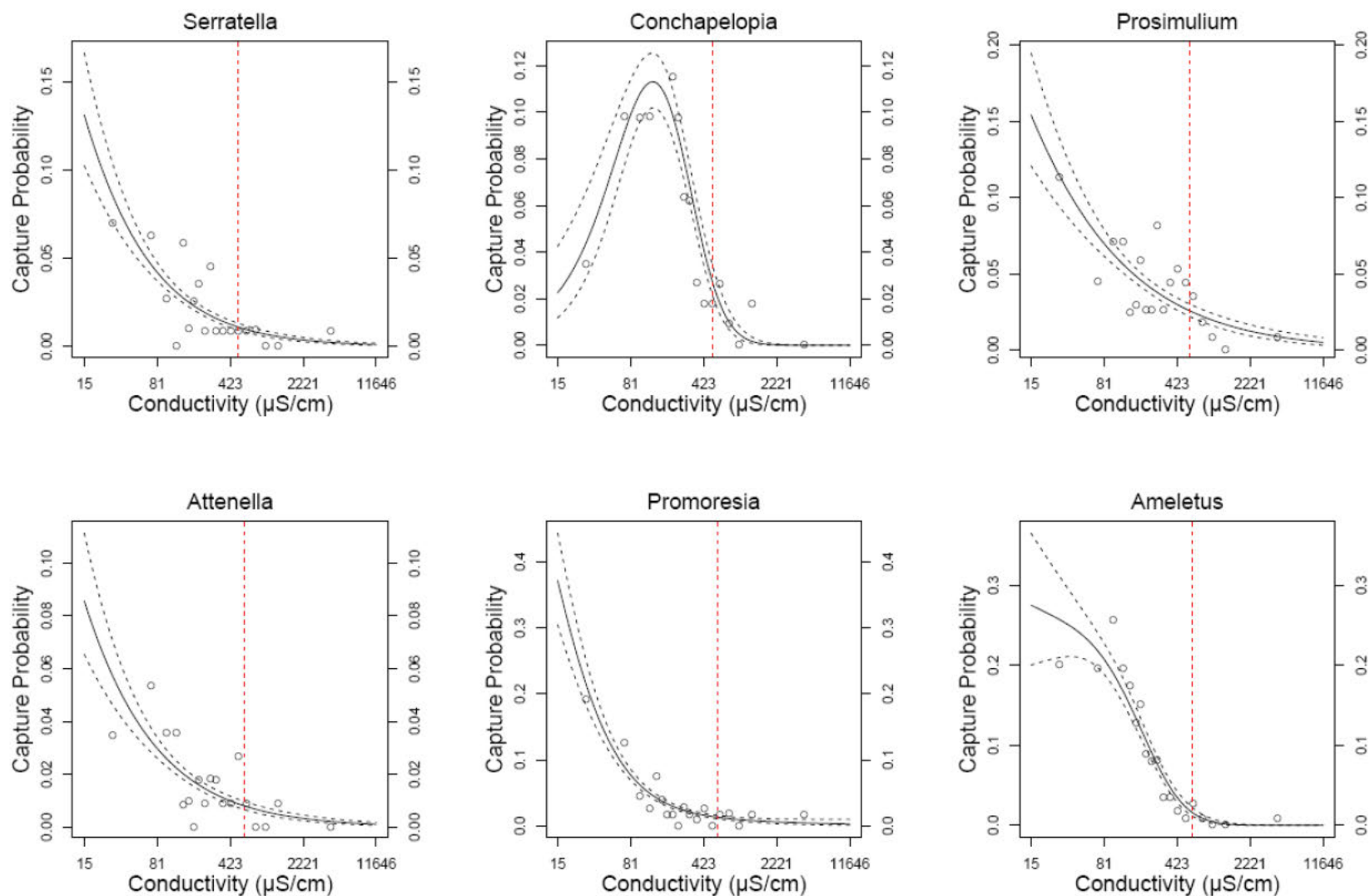


Figure D-1. Observation probabilities for each genus (continued).

# Capture Probability and Relative Abundance Along Conductivity Gradient

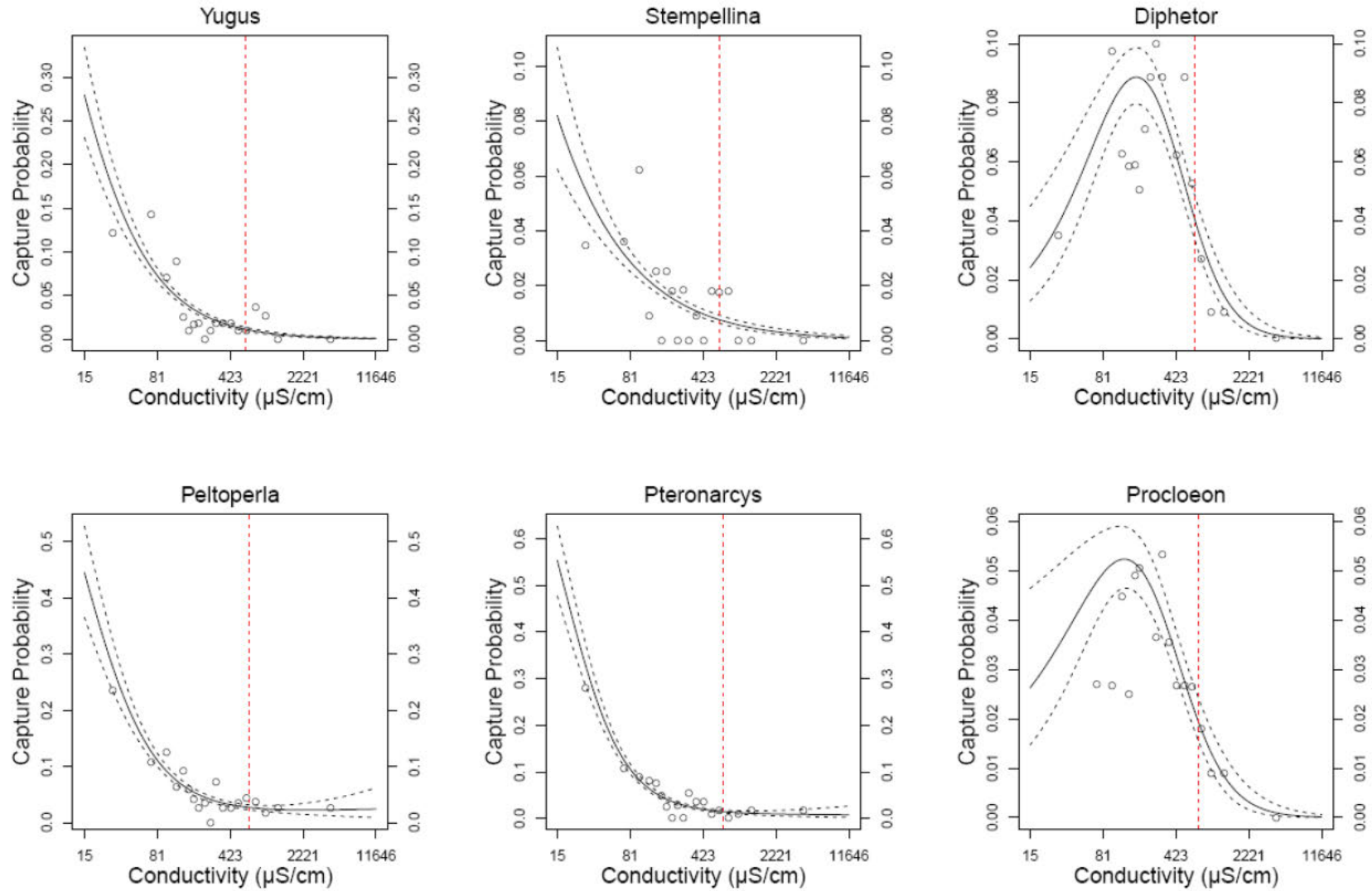


Figure D-1. Observation probabilities for each genus (continued).



## Capture Probability and Relative Abundance Along Conductivity Gradient

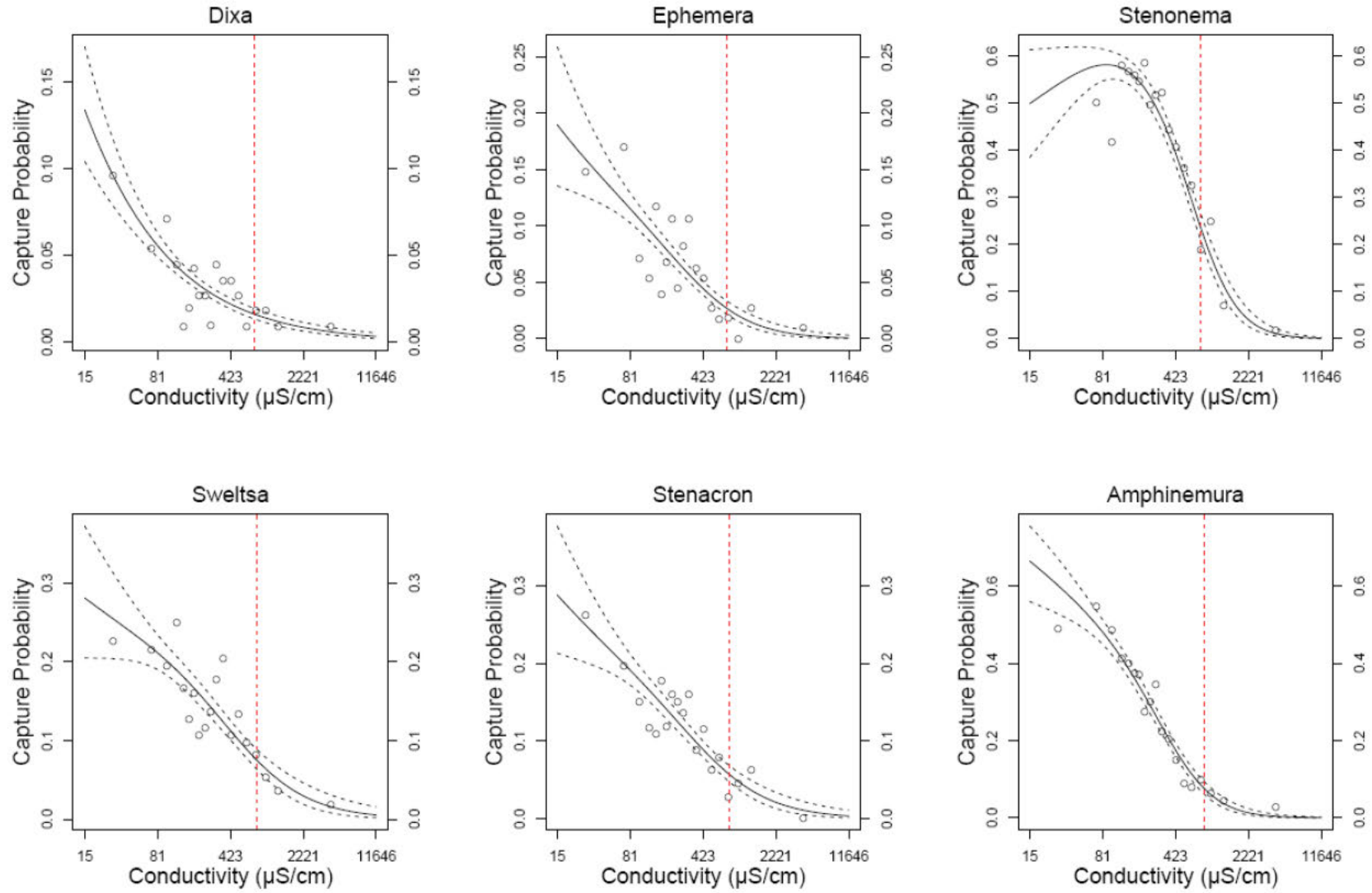


Figure D-1. Observation probabilities for each genus (continued).

## Capture Probability and Relative Abundance Along Conductivity Gradient

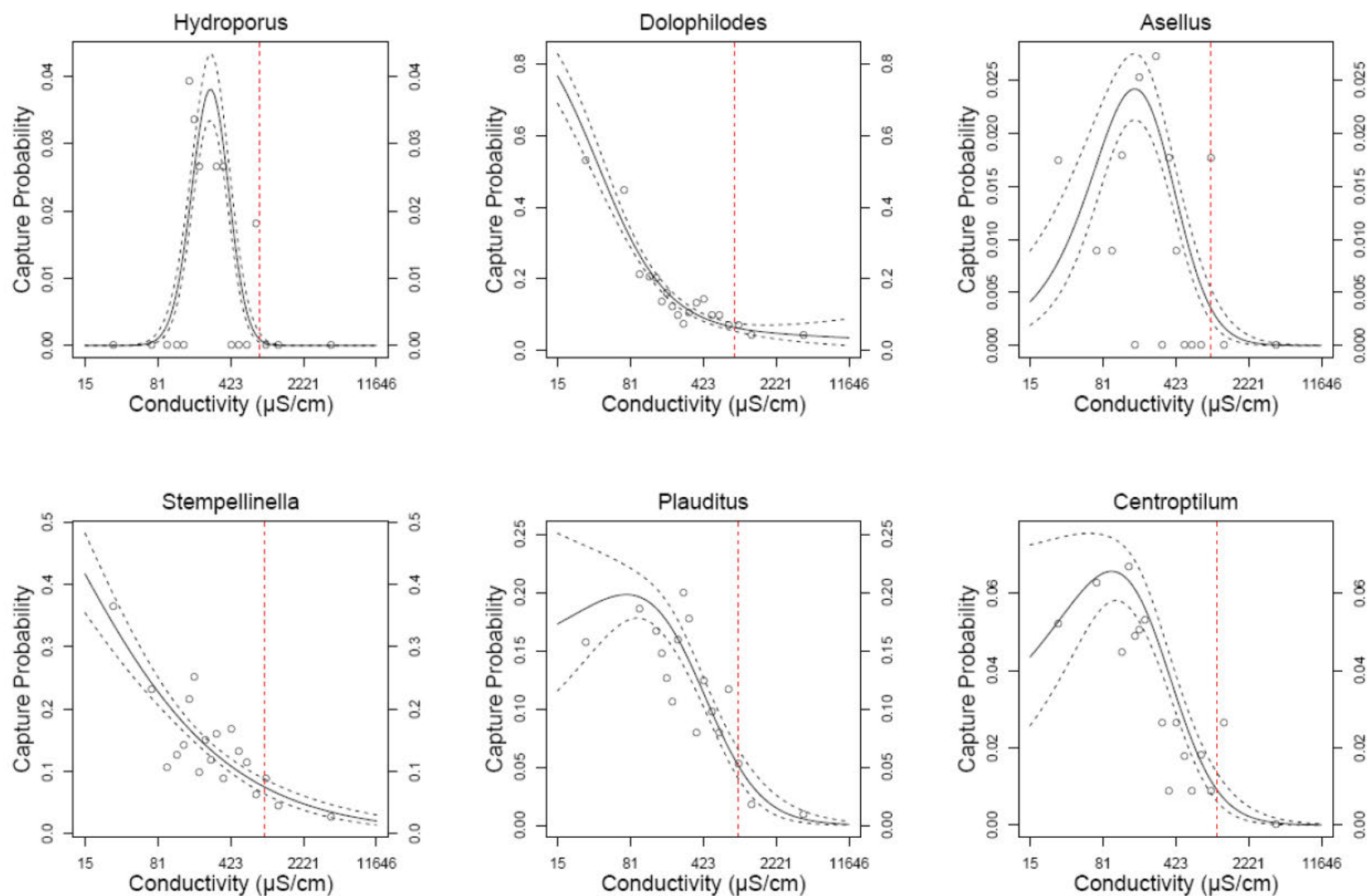


Figure D-1. Observation probabilities for each genus (continued).

# Capture Probability and Relative Abundance Along Conductivity Gradient

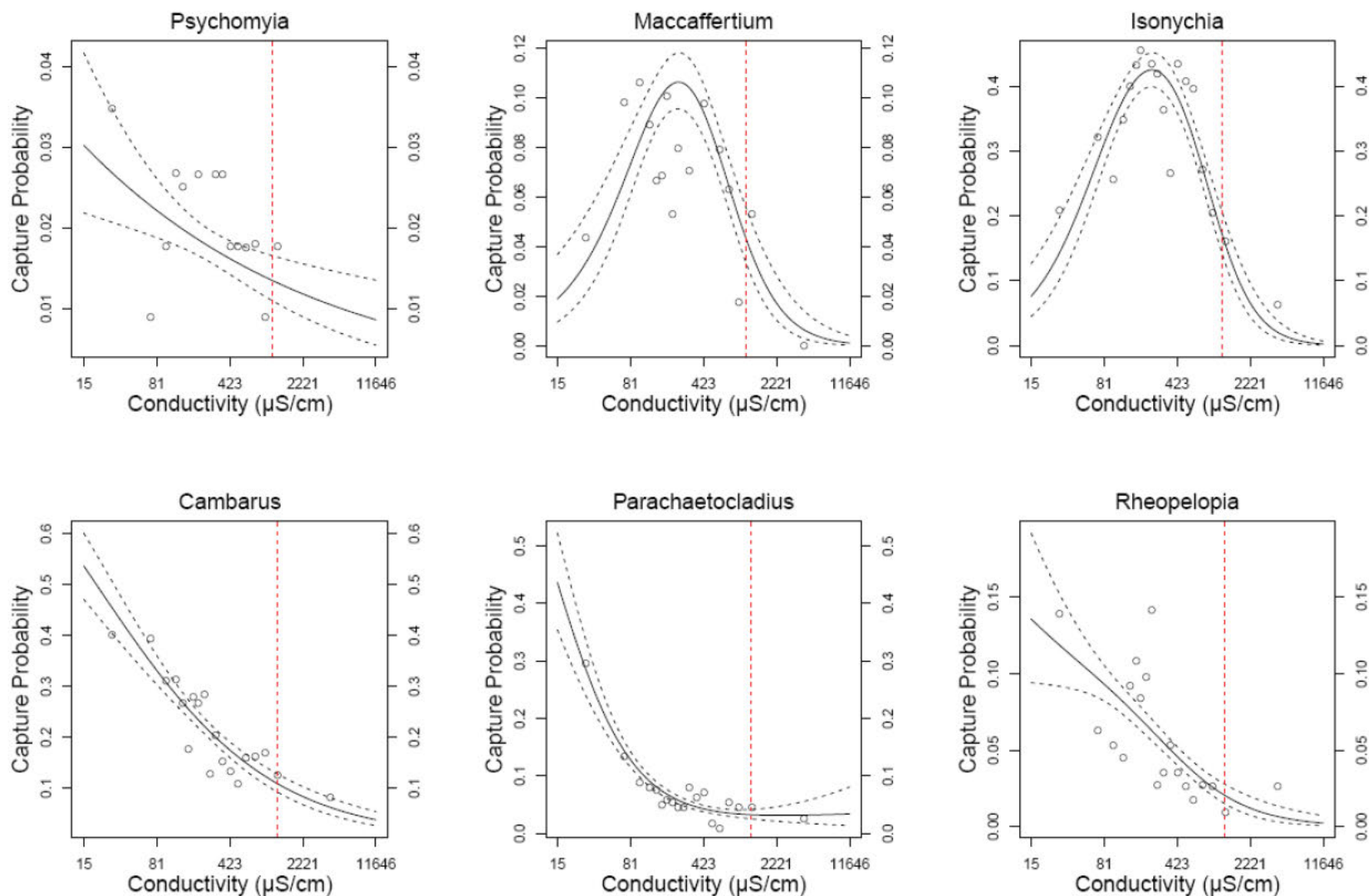


Figure D-1. Observation probabilities for each genus (continued).

# Capture Probability and Relative Abundance Along Conductivity Gradient

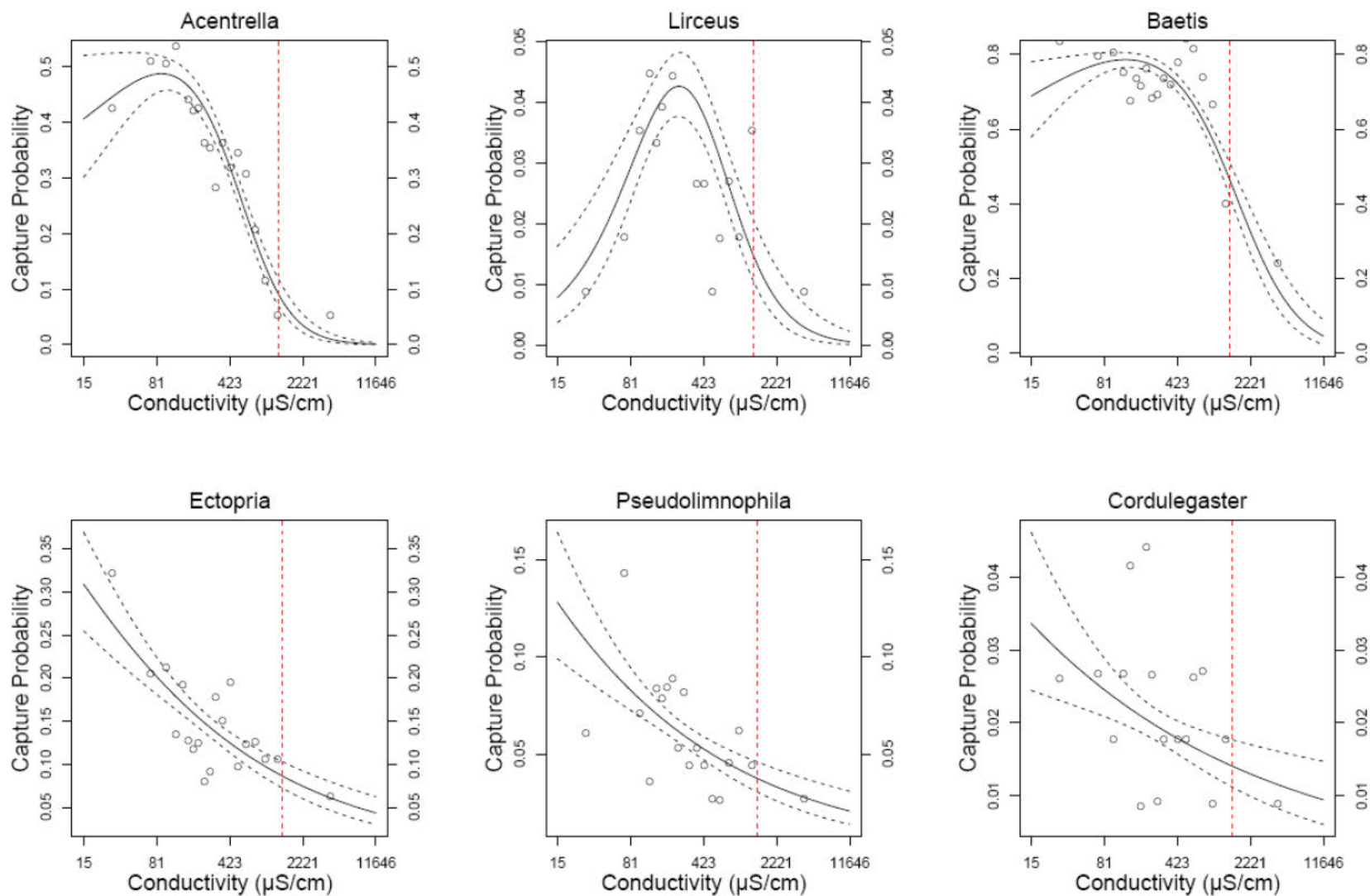


Figure D-1. Observation probabilities for each genus (continued).



# Capture Probability and Relative Abundance Along Conductivity Gradient

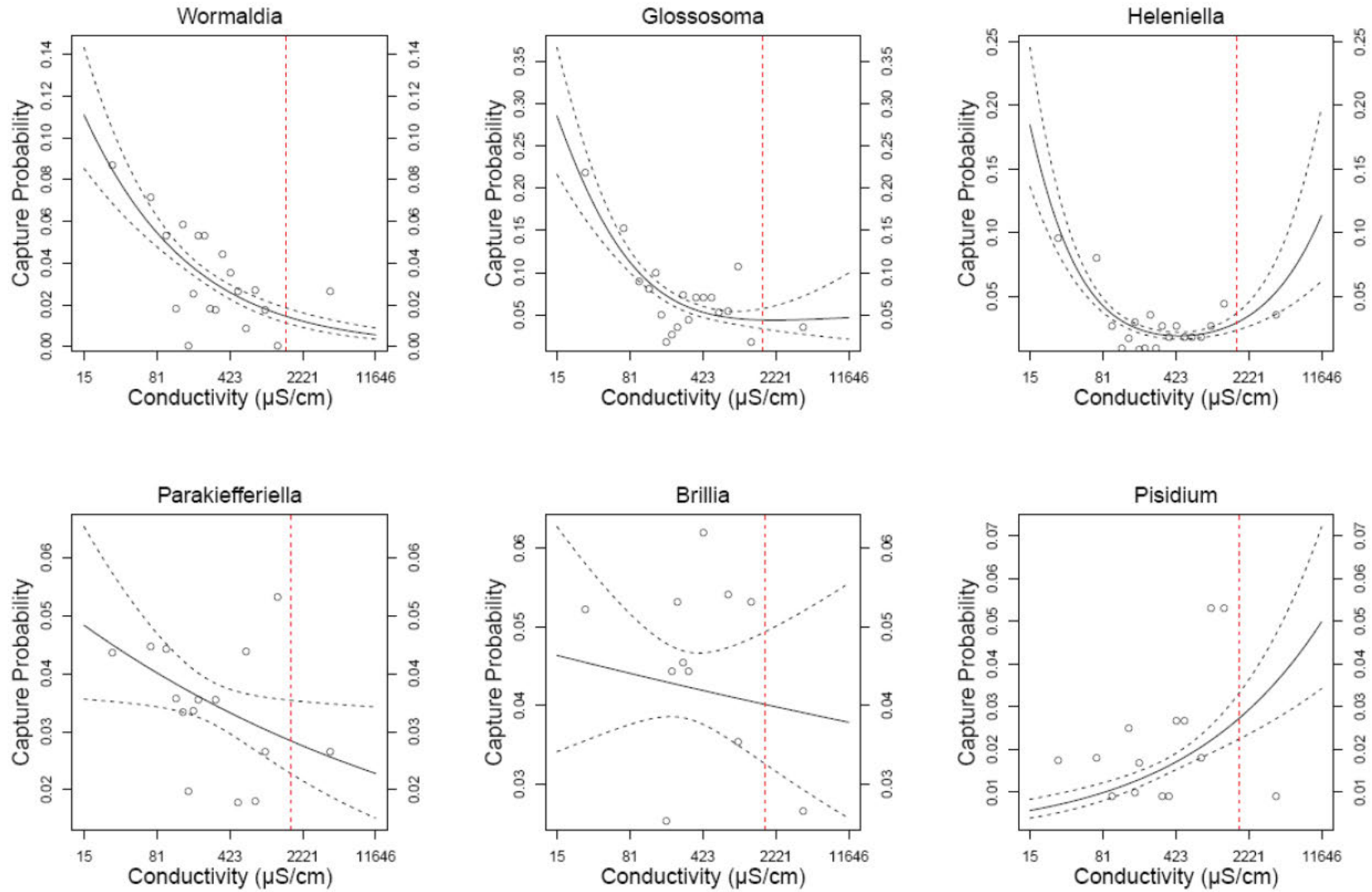


Figure D-1. Observation probabilities for each genus (continued).

# Capture Probability and Relative Abundance Along Conductivity Gradient

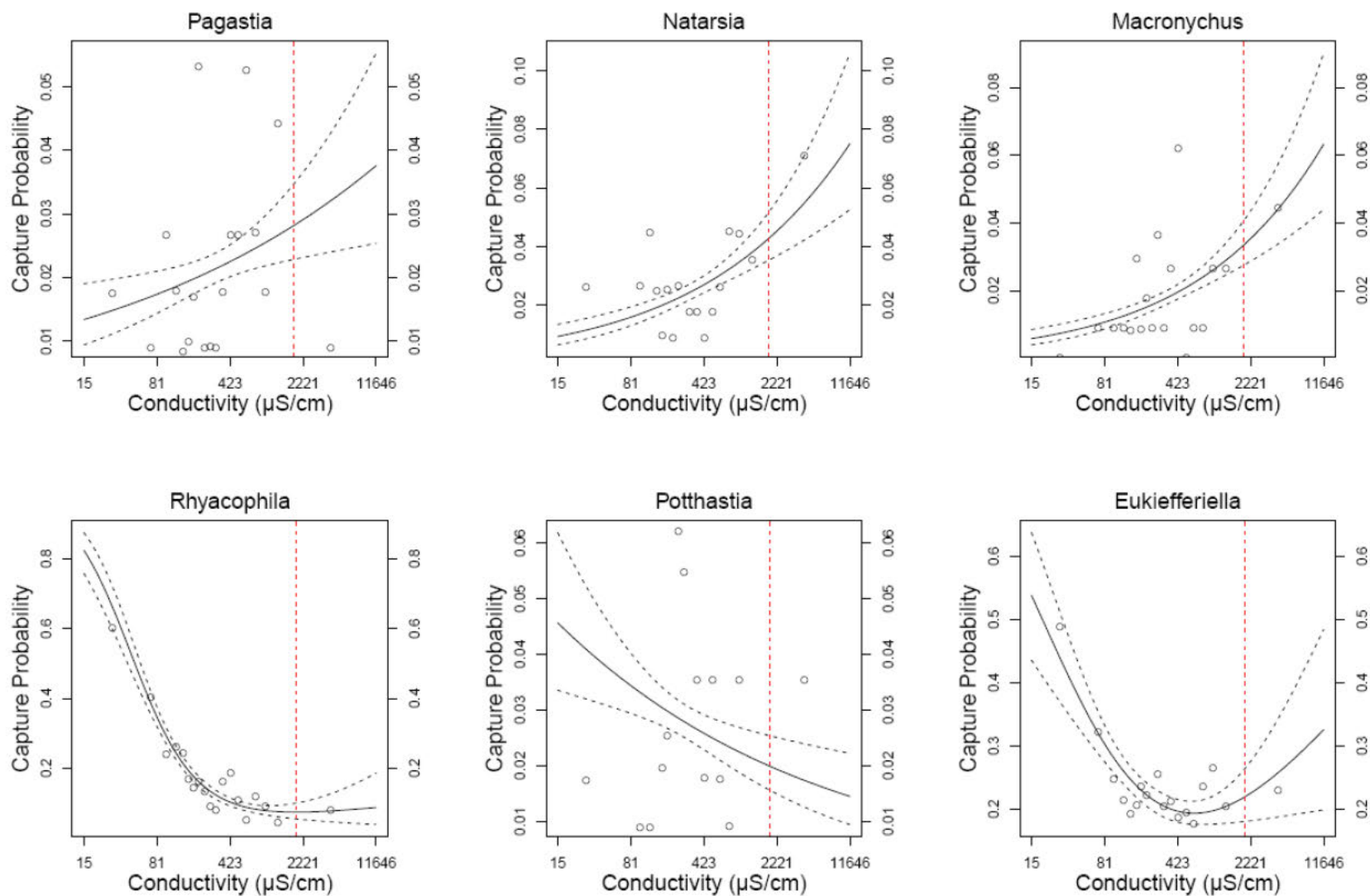


Figure D-1. Observation probabilities for each genus (continued).

# Capture Probability and Relative Abundance Along Conductivity Gradient

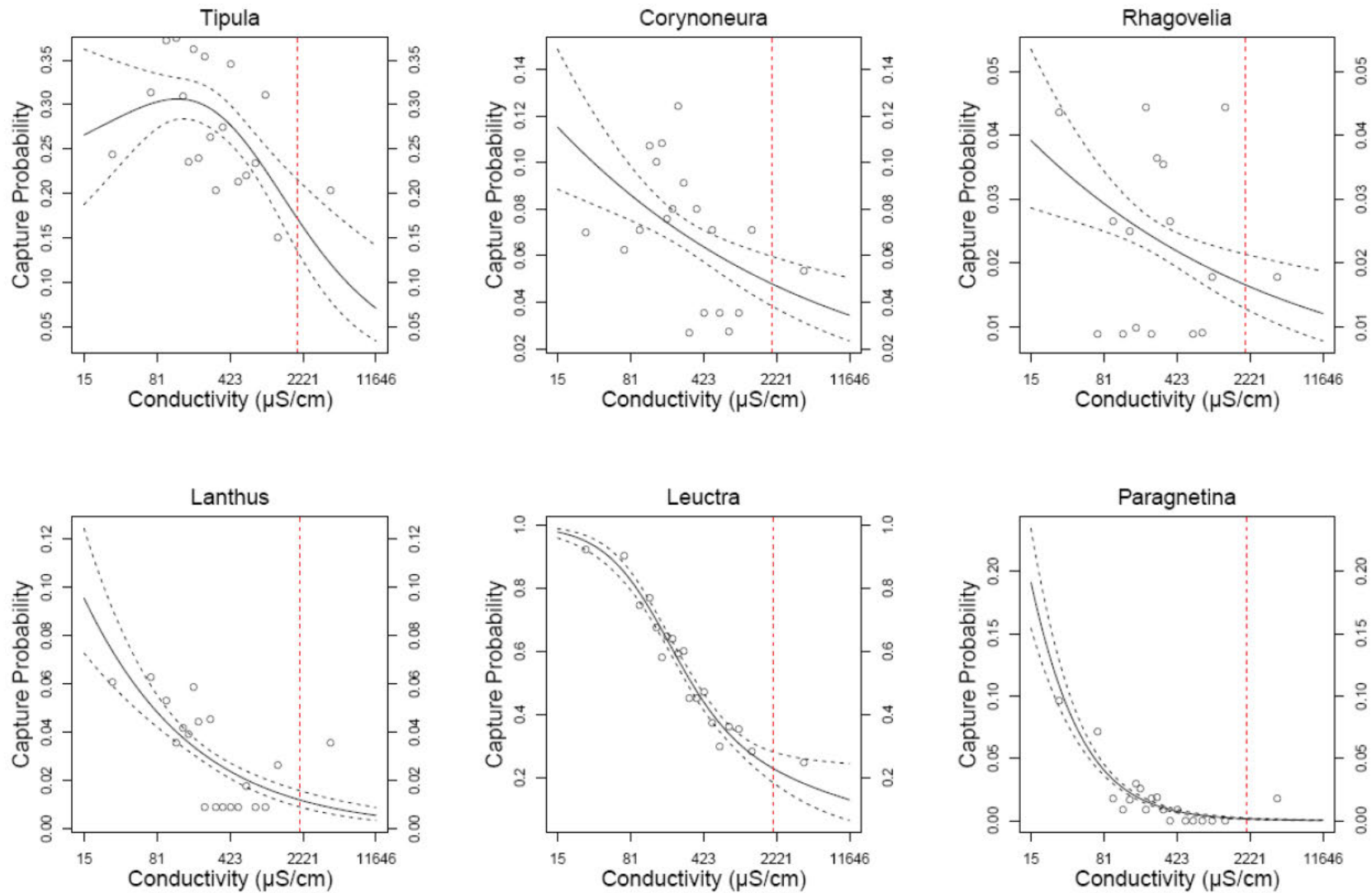


Figure D-1. Observation probabilities for each genus (continued).

# Capture Probability and Relative Abundance Along Conductivity Gradient

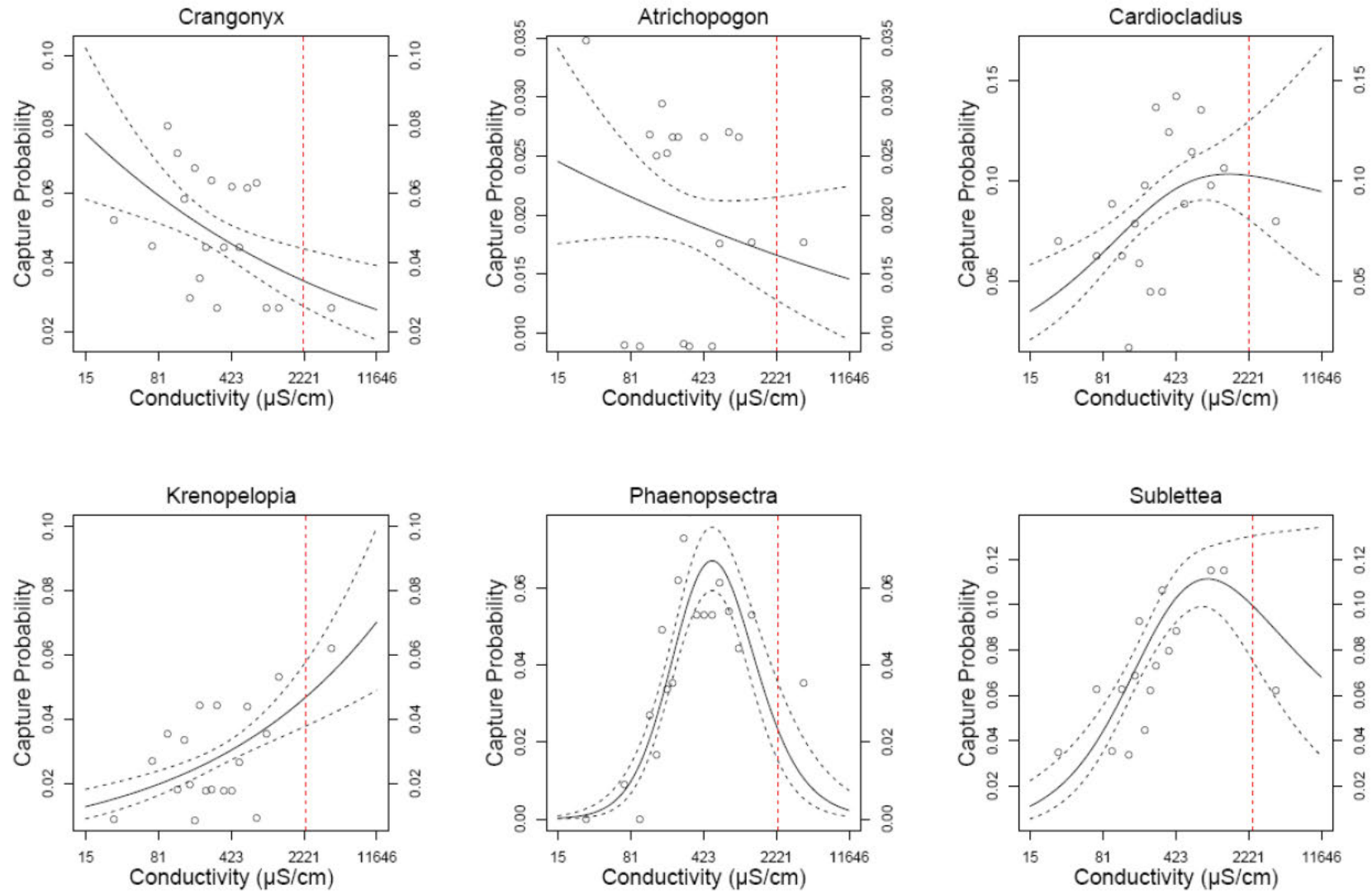


Figure D-1. Observation probabilities for each genus (continued).



# Capture Probability and Relative Abundance Along Conductivity Gradient

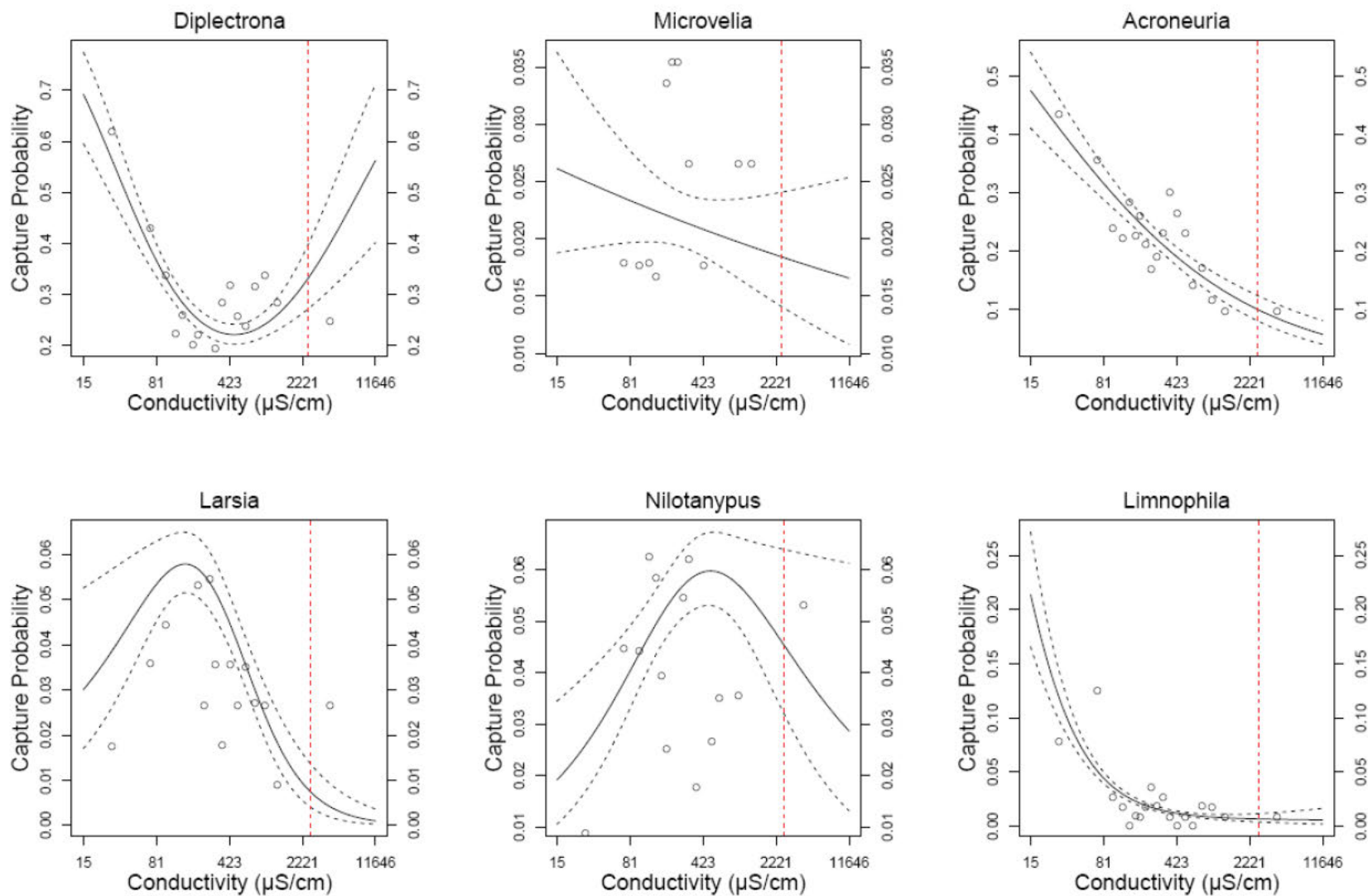


Figure D-1. Observation probabilities for each genus (continued).

# Capture Probability and Relative Abundance Along Conductivity Gradient

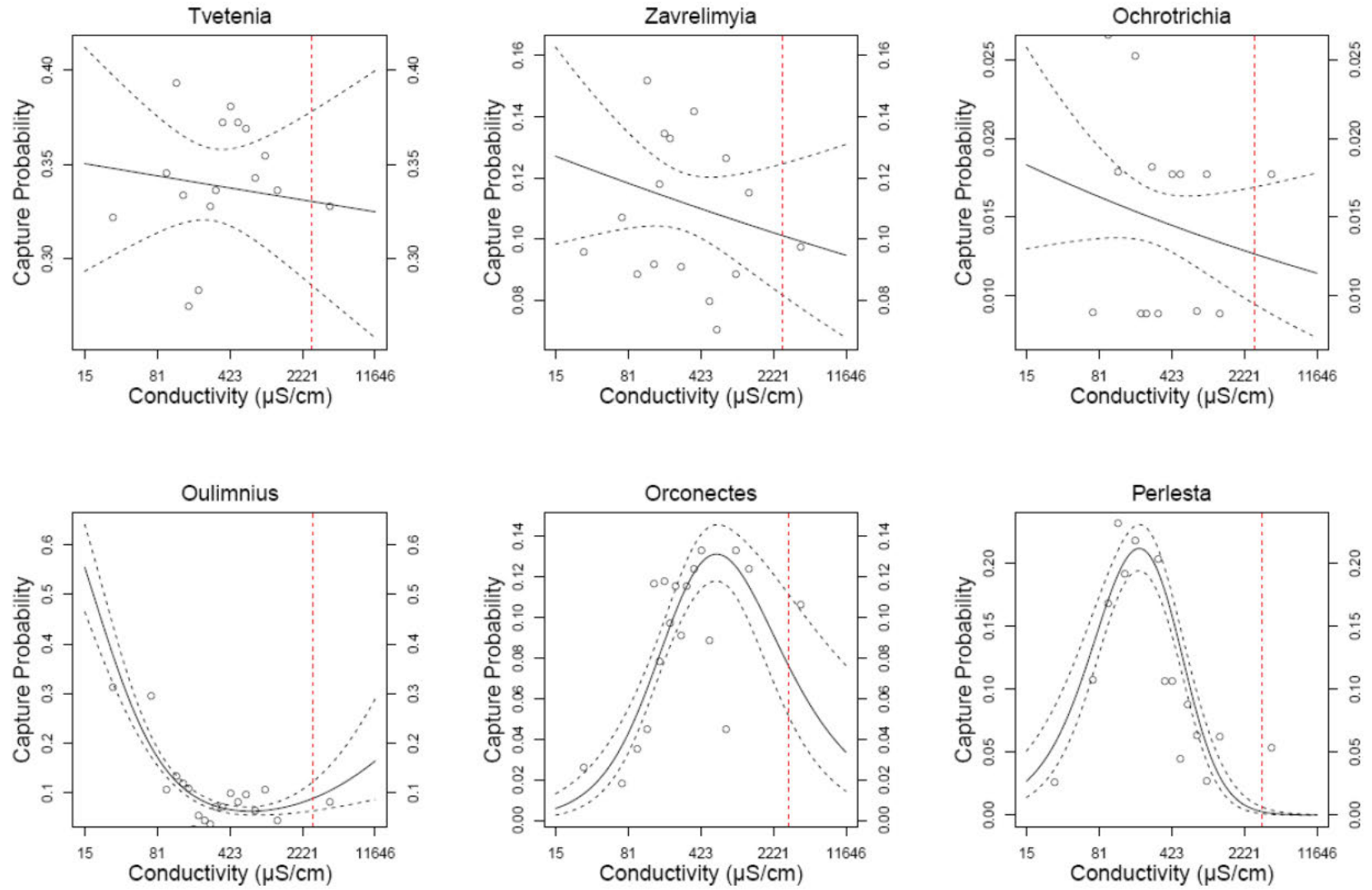


Figure D-1. Observation probabilities for each genus (continued).

# Capture Probability and Relative Abundance Along Conductivity Gradient

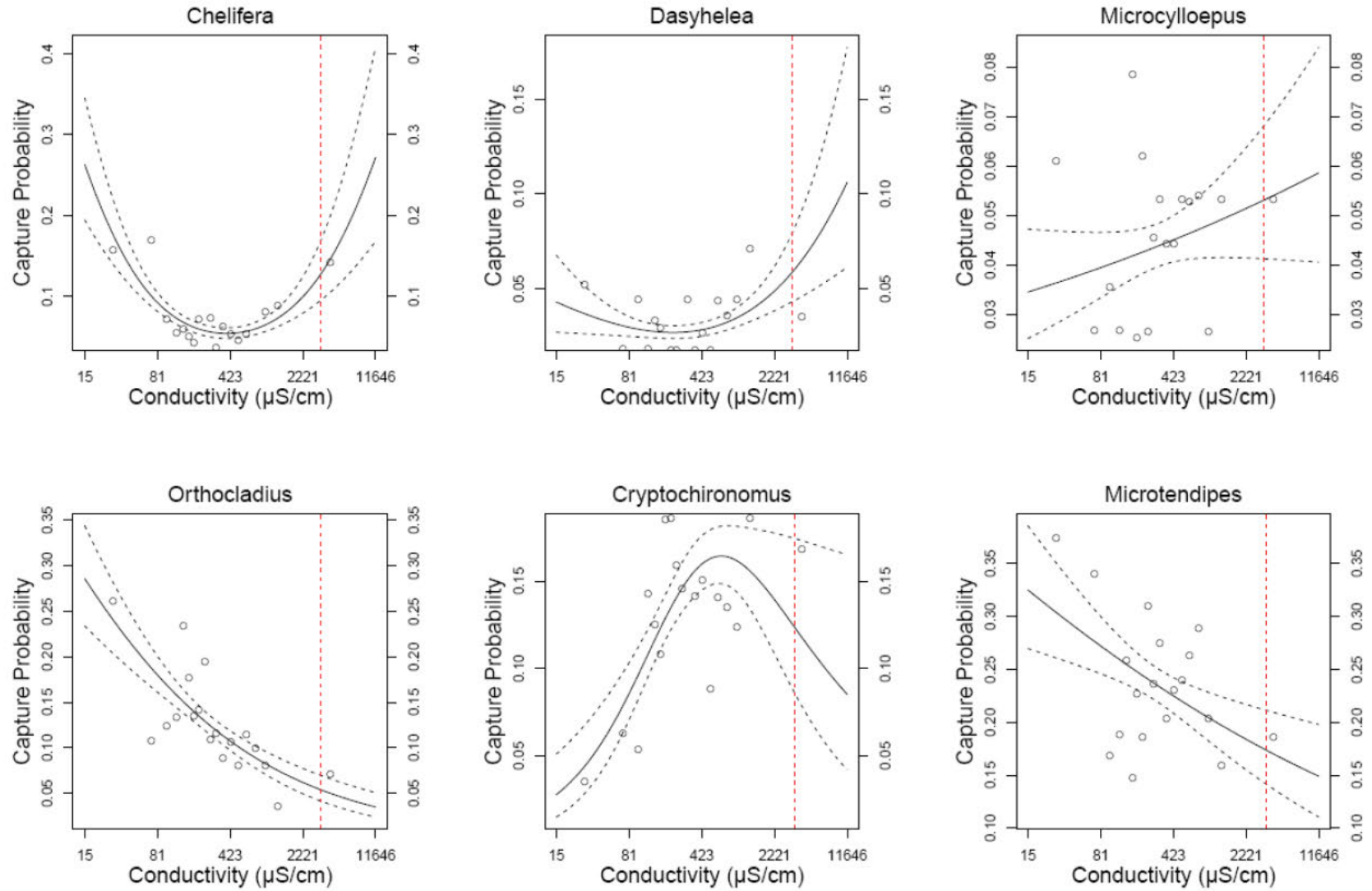


Figure D-1. Observation probabilities for each genus (continued).

## Capture Probability and Relative Abundance Along Conductivity Gradient

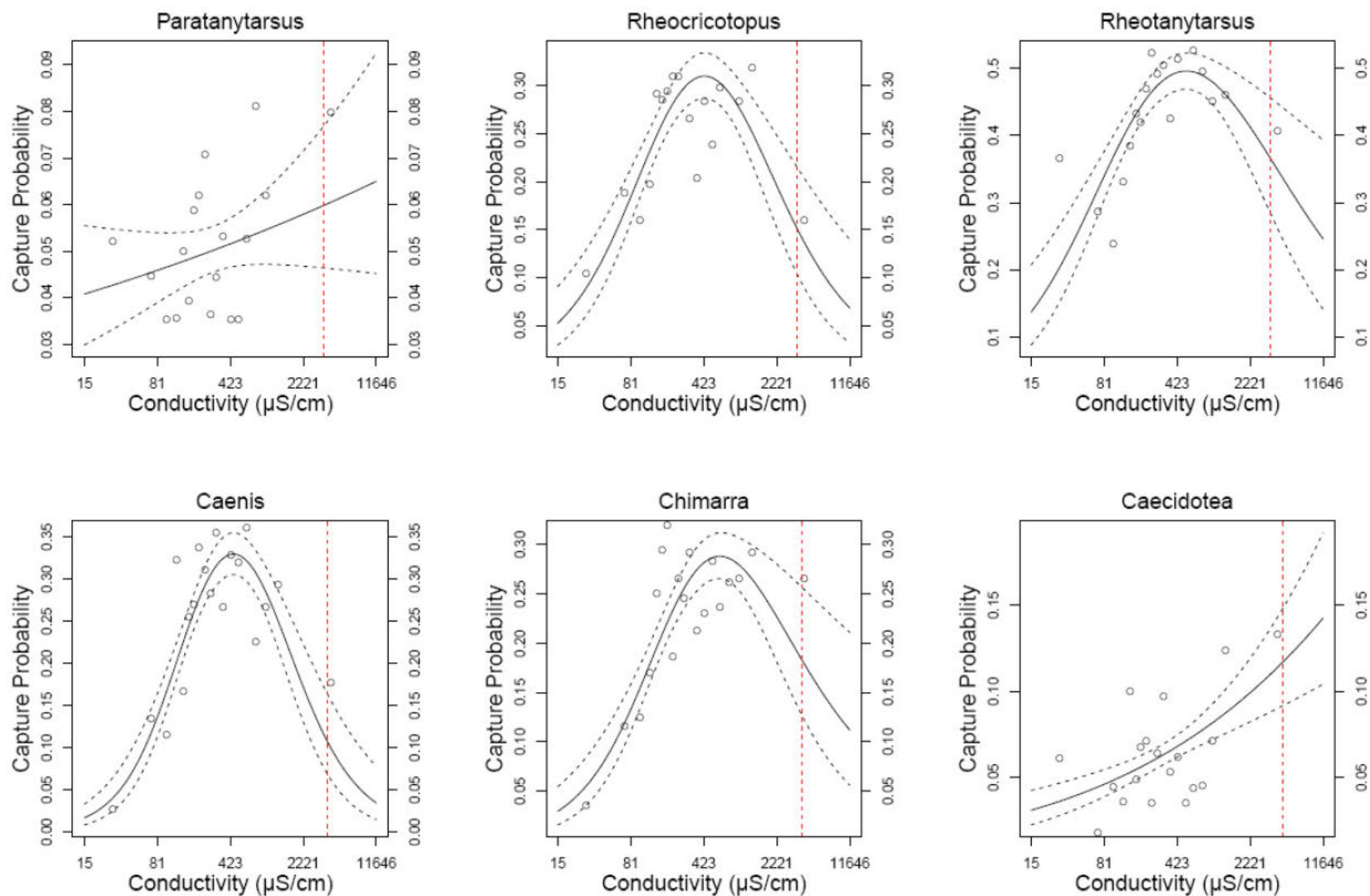


Figure D-1. Observation probabilities for each genus (continued).



## Capture Probability and Relative Abundance Along Conductivity Gradient

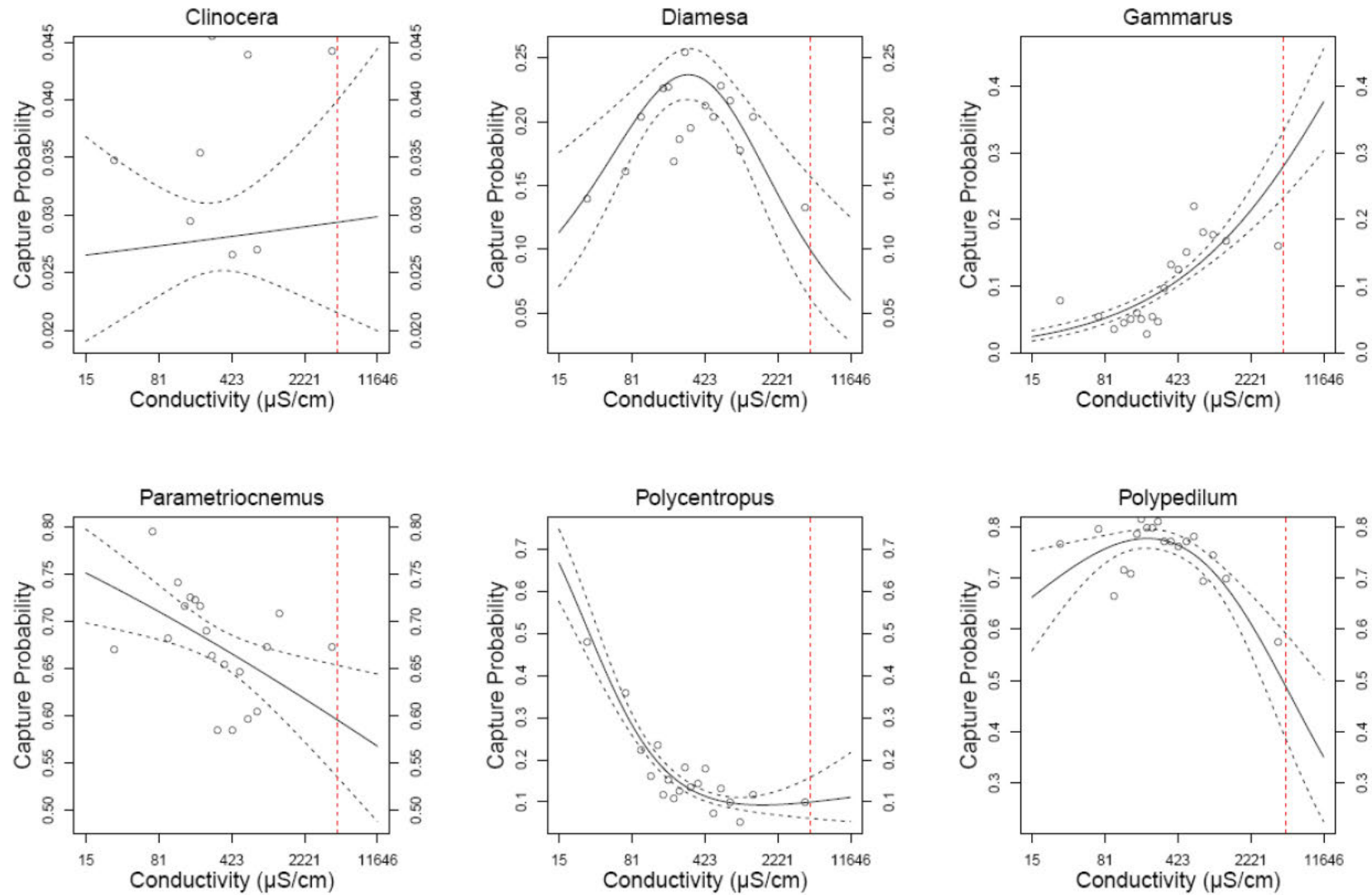


Figure D-1. Observation probabilities for each genus (continued).

# Capture Probability and Relative Abundance Along Conductivity Gradient

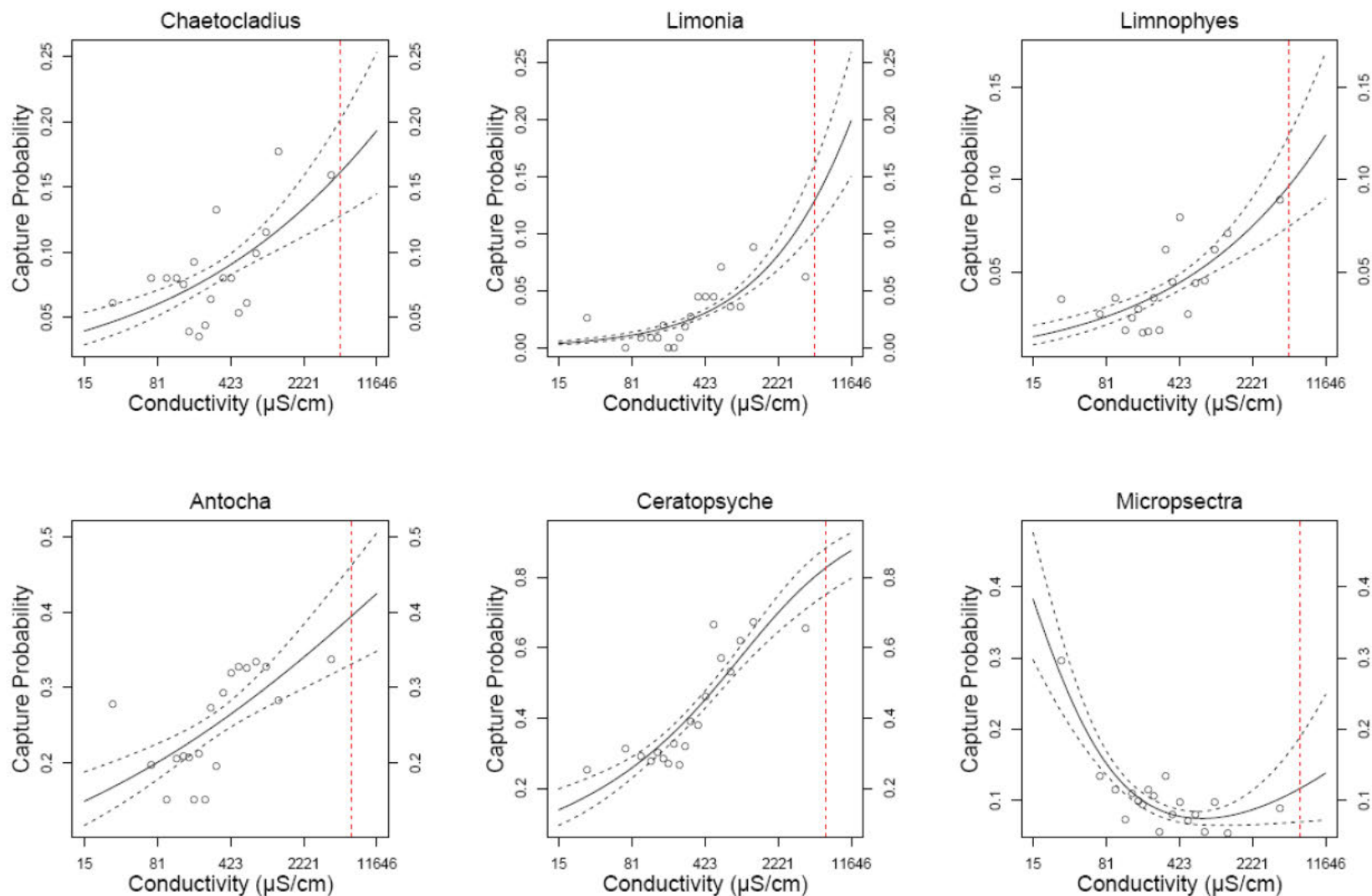


Figure D-1. Observation probabilities for each genus (continued).

## Capture Probability and Relative Abundance Along Conductivity Gradient

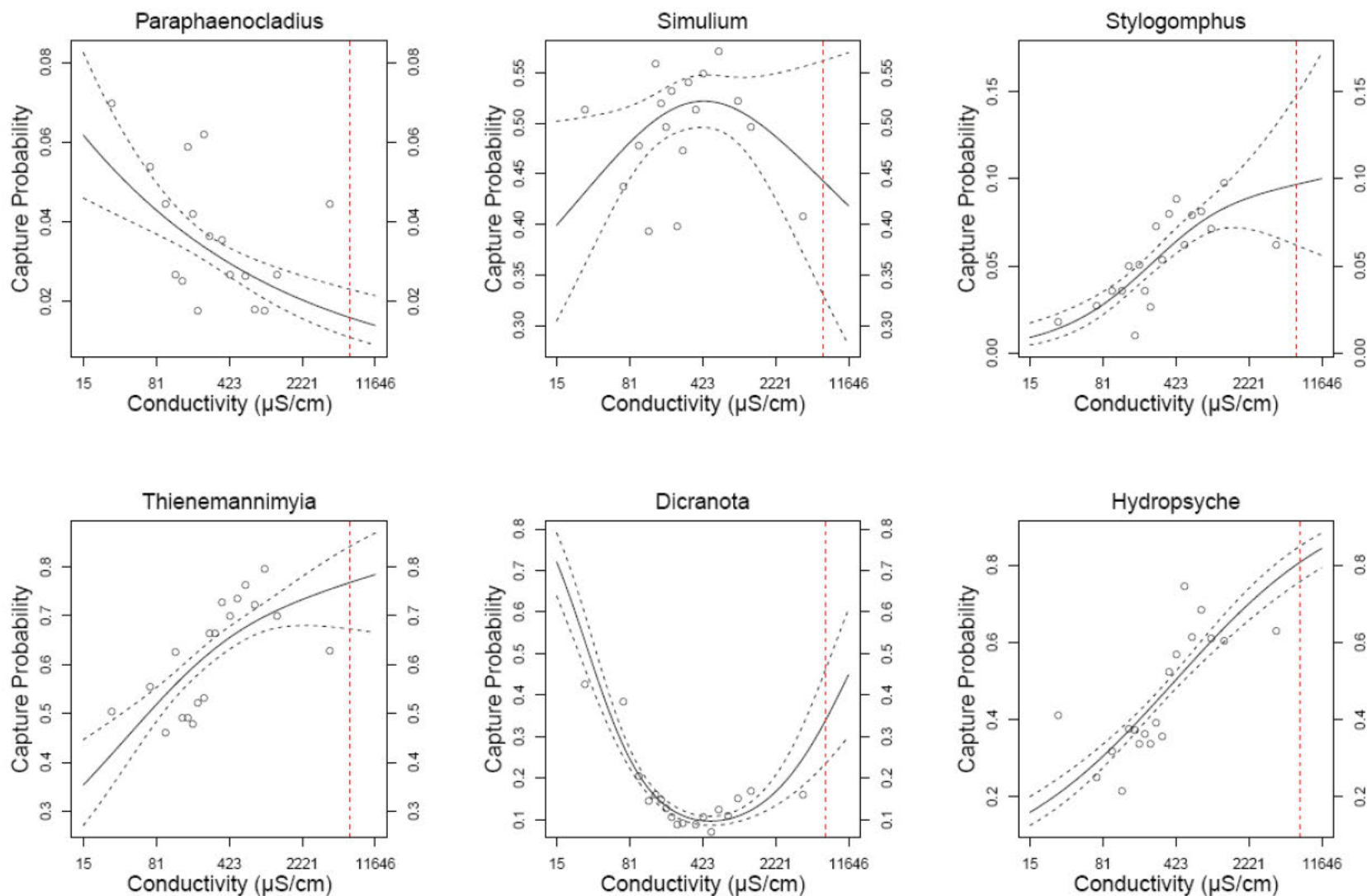


Figure D-1. Observation probabilities for each genus (continued).

# Capture Probability and Relative Abundance Along Conductivity Gradient

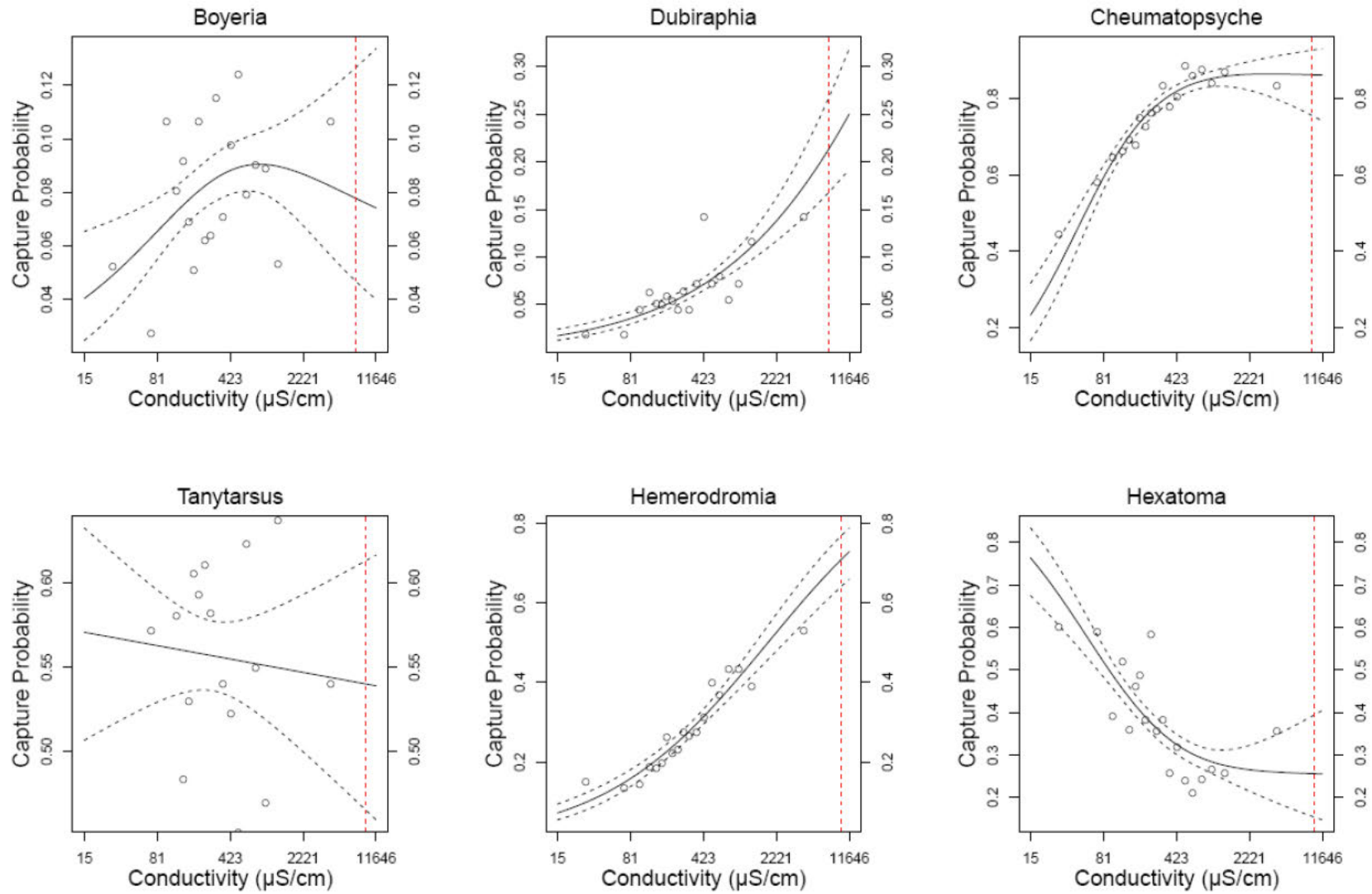


Figure D-1. Observation probabilities for each genus (continued).



# Capture Probability and Relative Abundance Along Conductivity Gradient

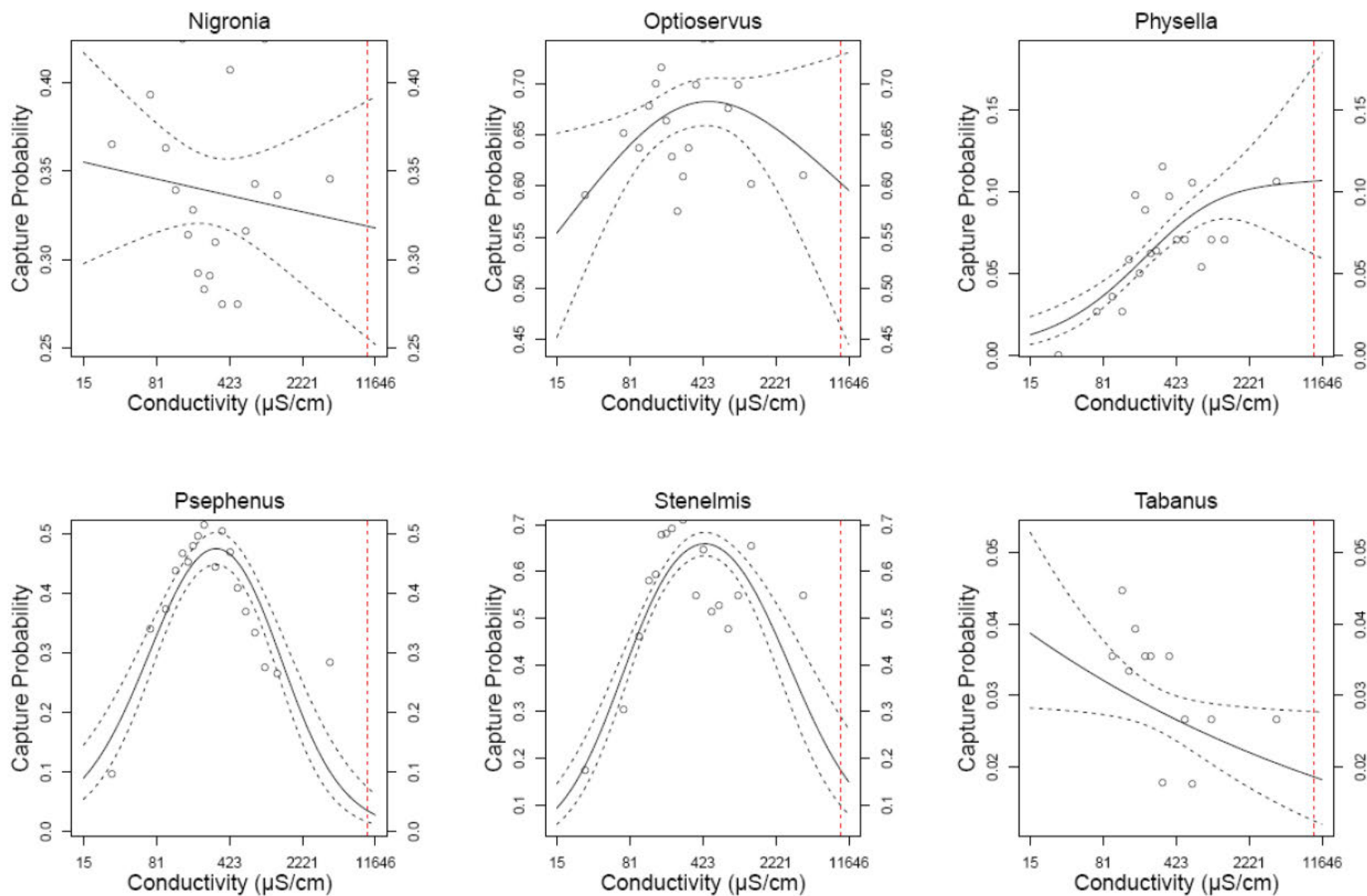


Figure D-1. Observation probabilities for each genus (continued).

## Capture Probability and Relative Abundance Along Conductivity Gradient

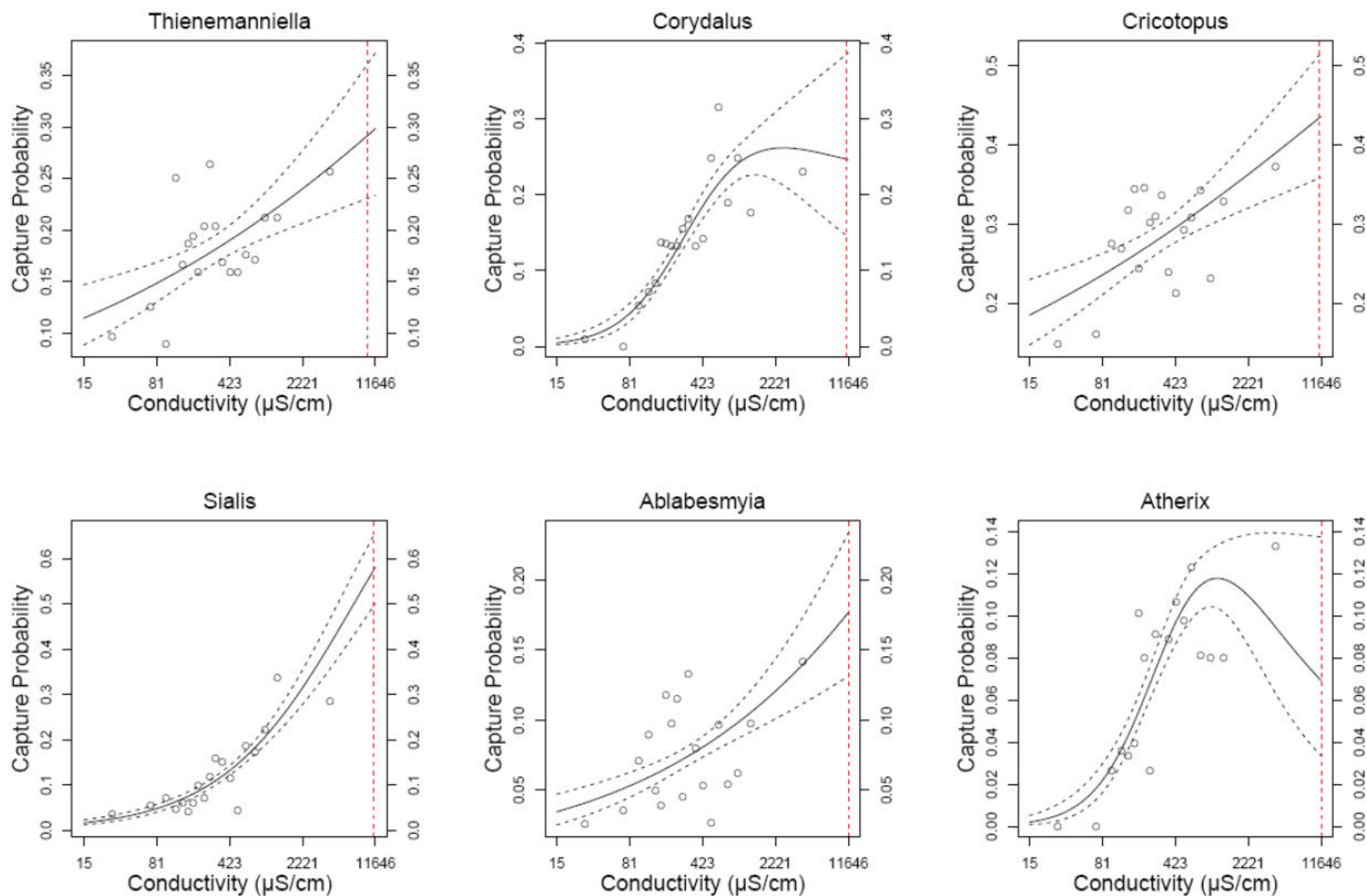


Figure D-1. Observation probabilities for each genus (continued).

# Capture Probability and Relative Abundance Along Conductivity Gradient

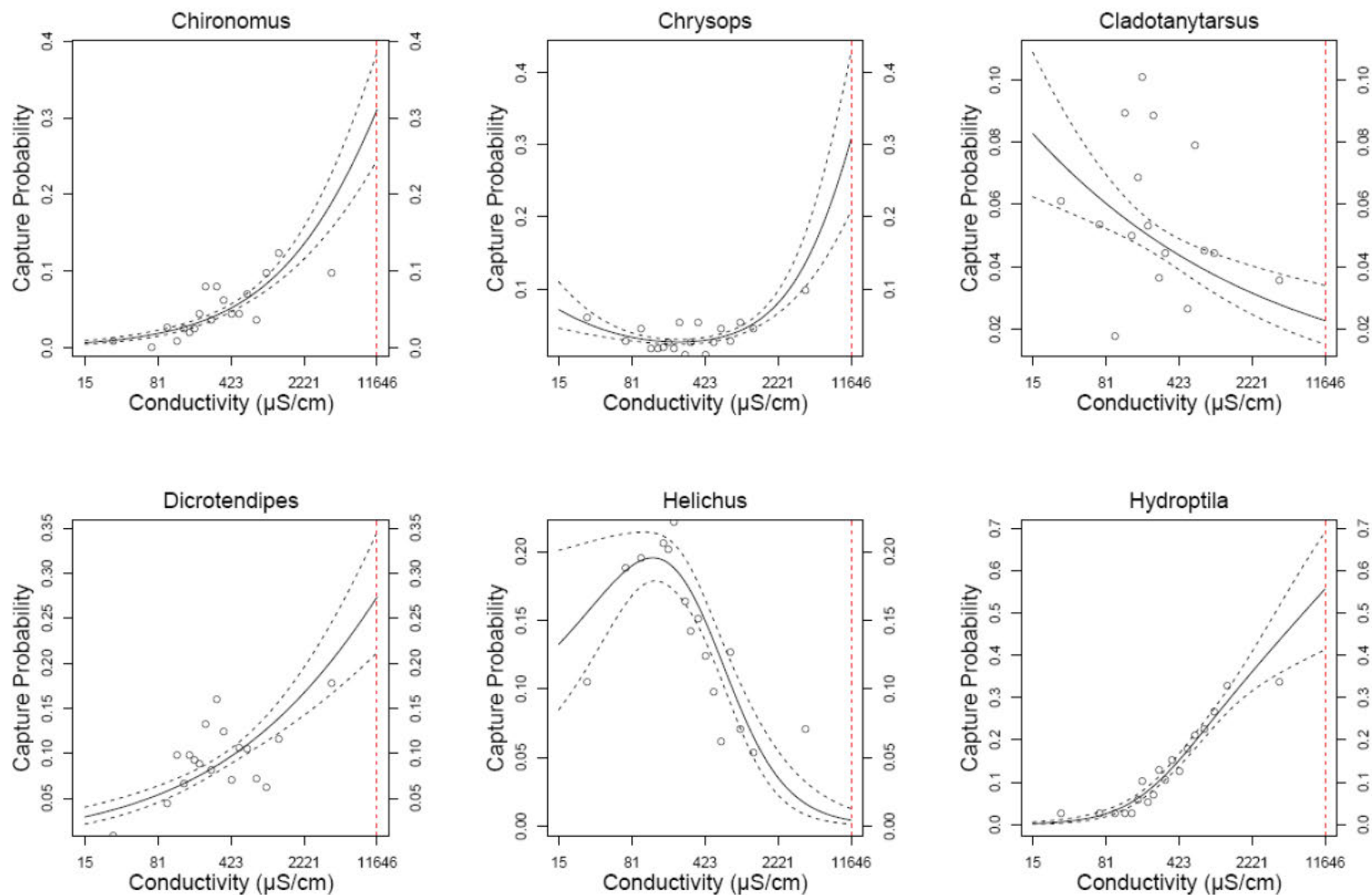


Figure D-1. Observation probabilities for each genus (continued).

## Capture Probability and Relative Abundance Along Conductivity Gradient

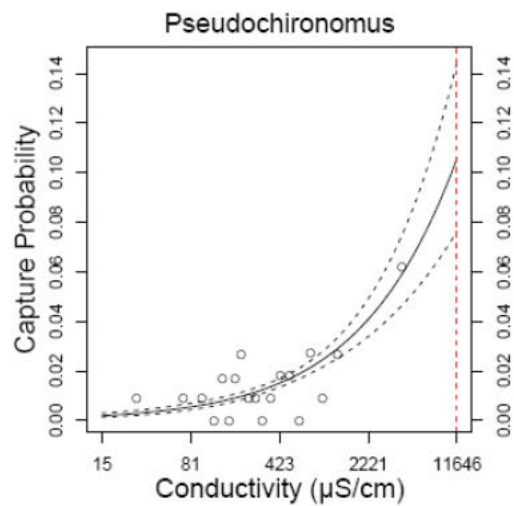
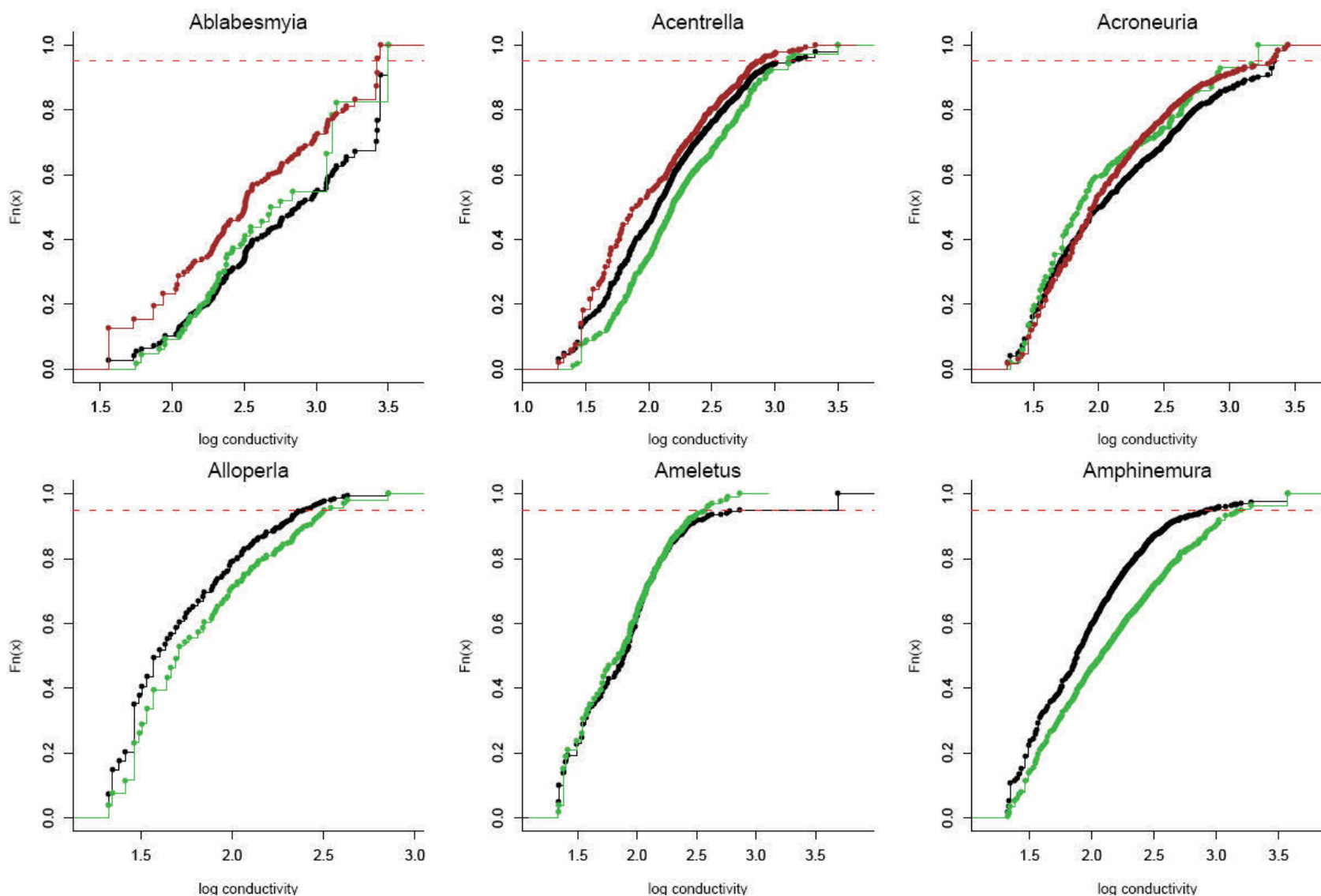
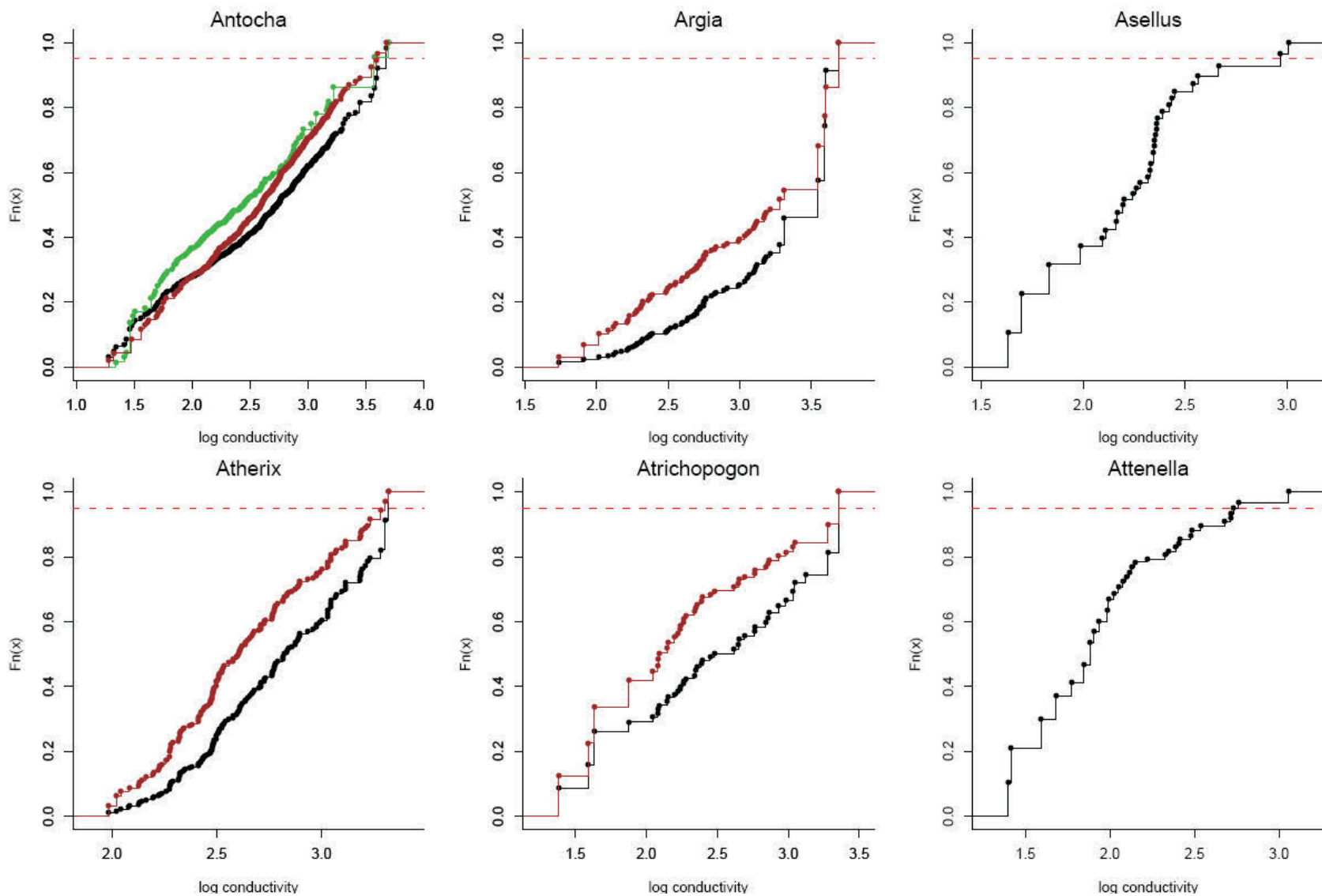


Figure D-1. Observation probabilities for each genus (continued).

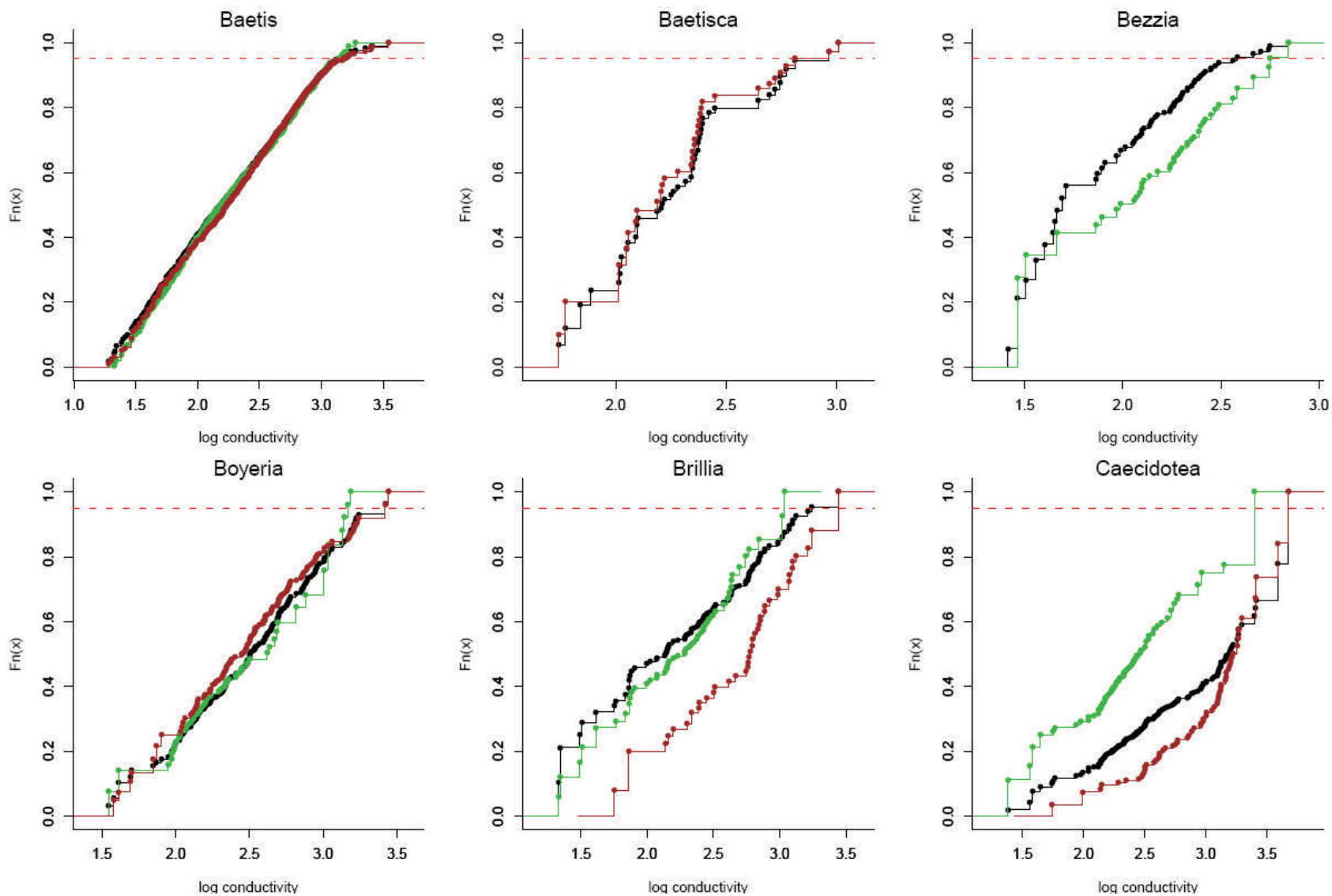


**Figure D-2. Cumulative distribution functions of observation probabilities weighted by sampling frequency for each genus. Sites with pH <6 excluded.**

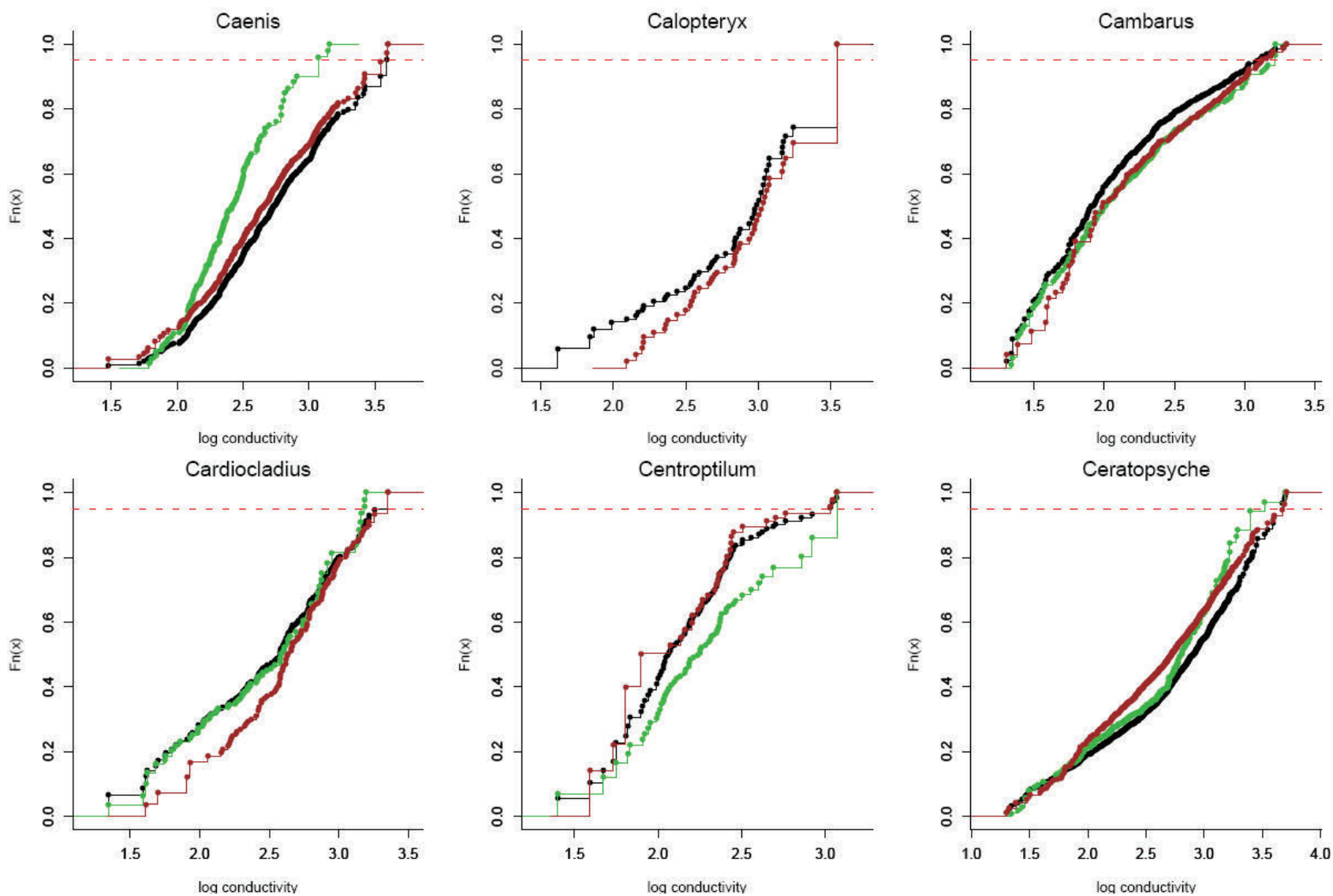




**Figure D-2. Cumulative distribution functions of observation probabilities weighted by sampling frequency for each genus (continued).**

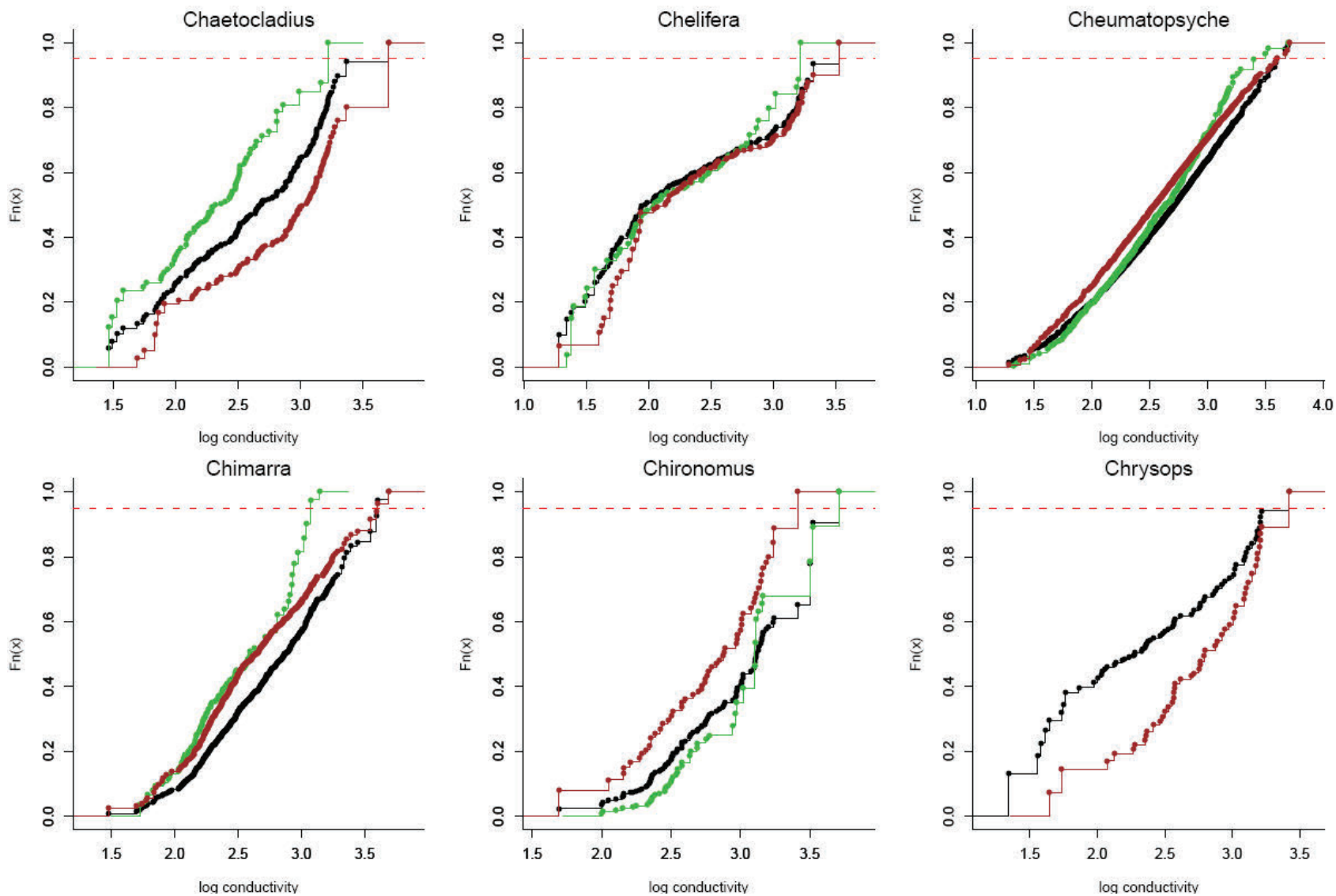


**Figure D-2. Cumulative distribution functions of observation probabilities weighted by sampling frequency for each genus (continued).**

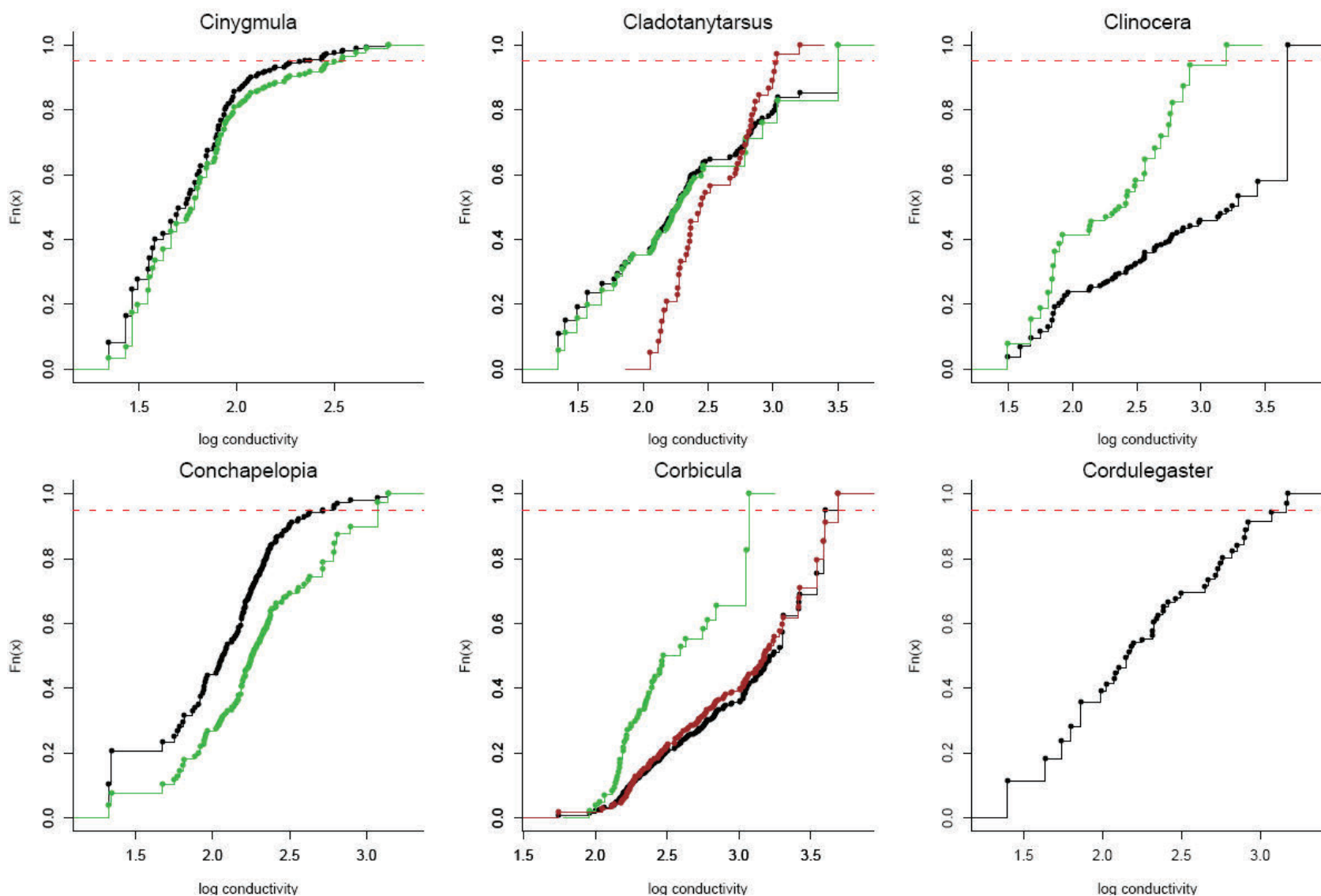


**Figure D-2. Cumulative distribution functions of observation probabilities weighted by sampling frequency for each genus (continued).**

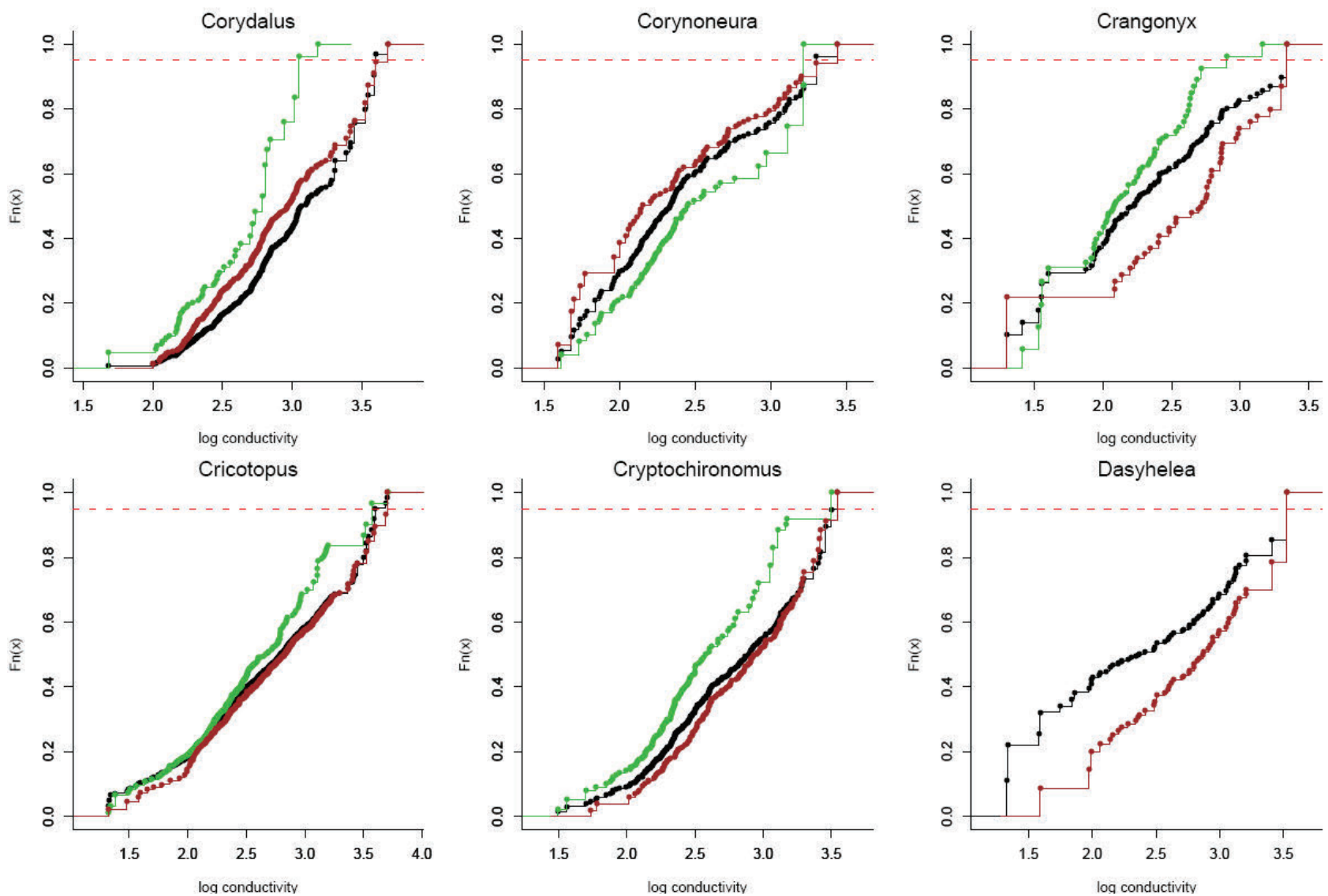




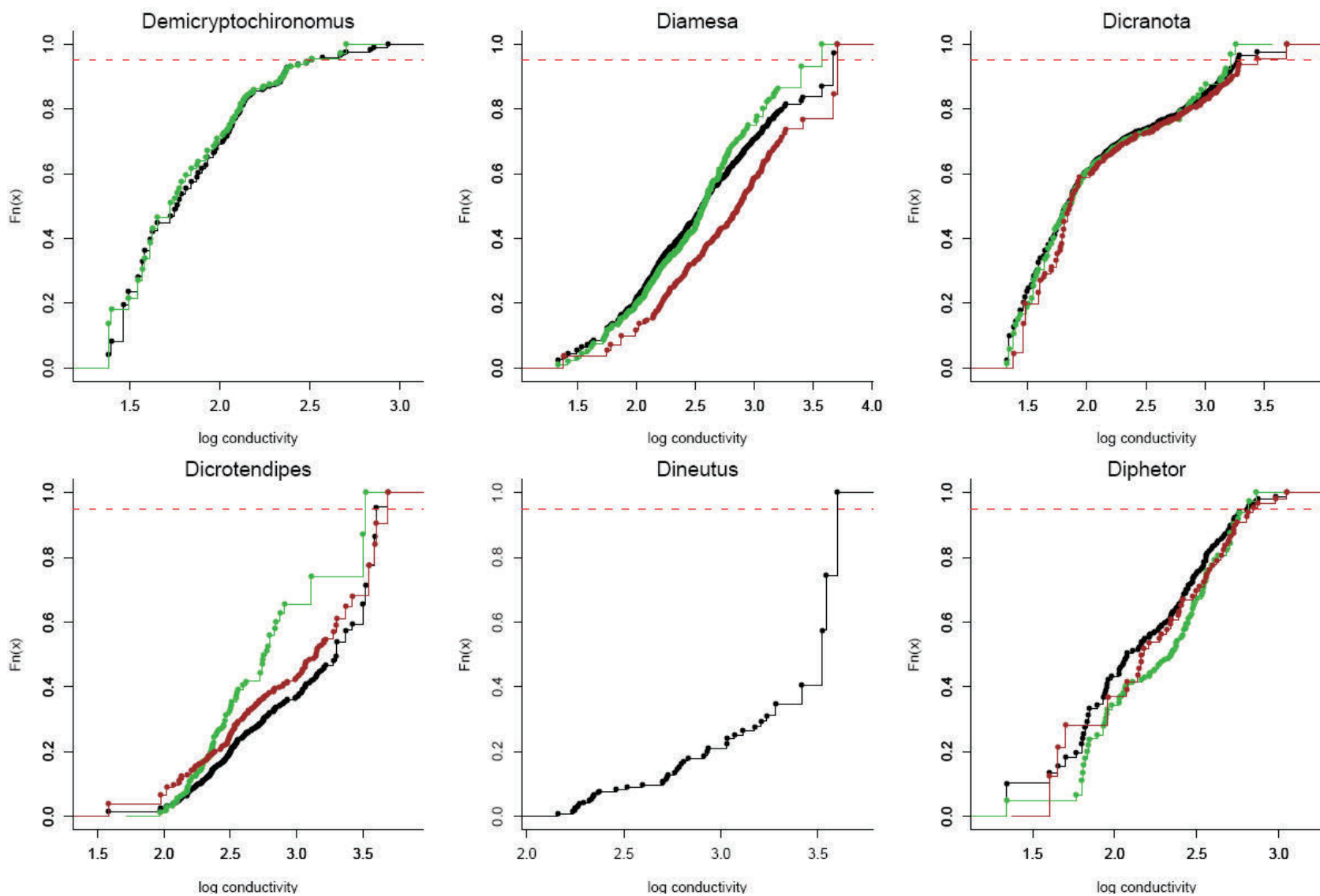
**Figure D-2. Cumulative distribution functions of observation probabilities weighted by sampling frequency for each genus (continued).**



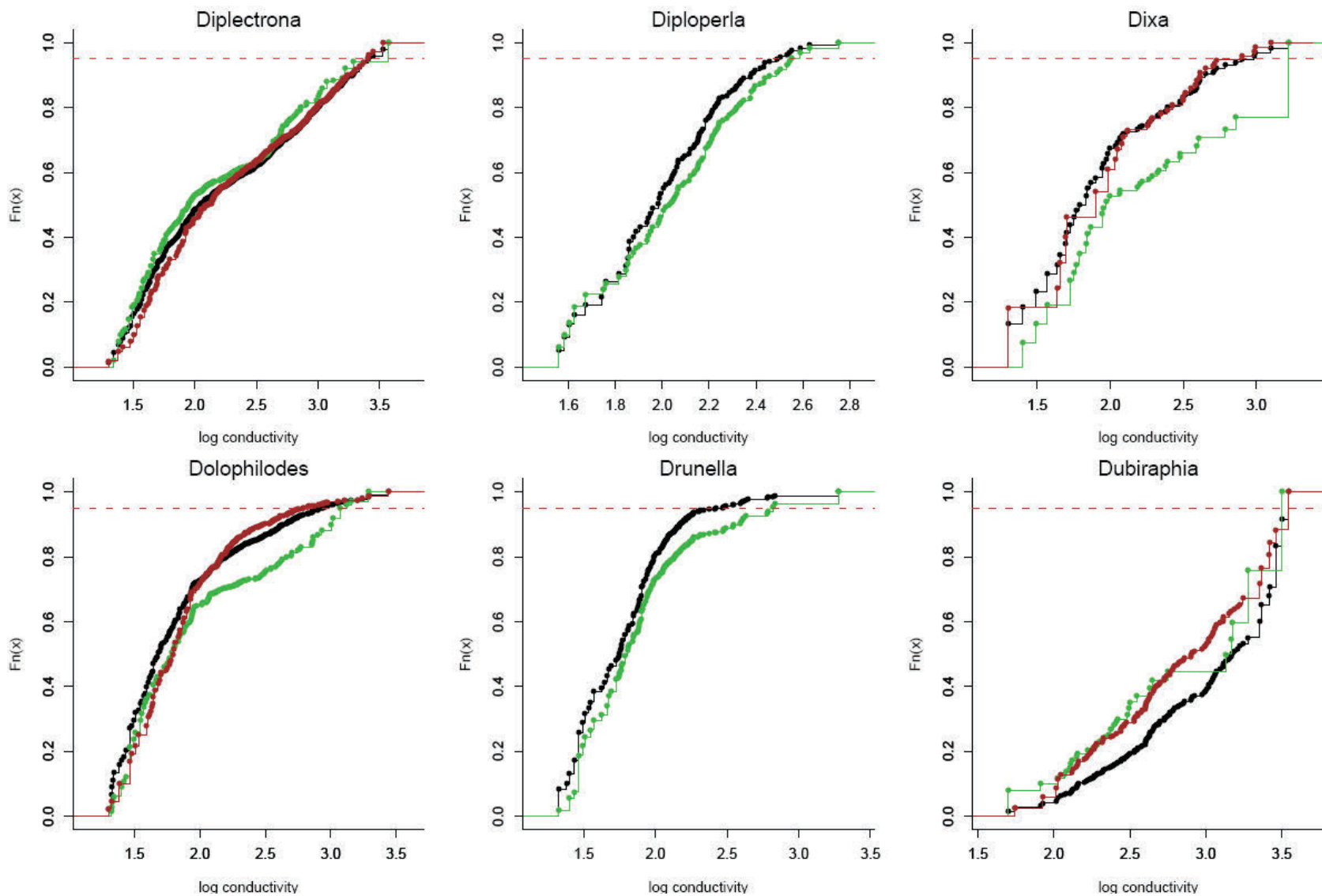
**Figure D-2. Cumulative distribution functions of observation probabilities weighted by sampling frequency for each genus (continued).**



**Figure D-2. Cumulative distribution functions of observation probabilities weighted by sampling frequency for each genus (continued).**

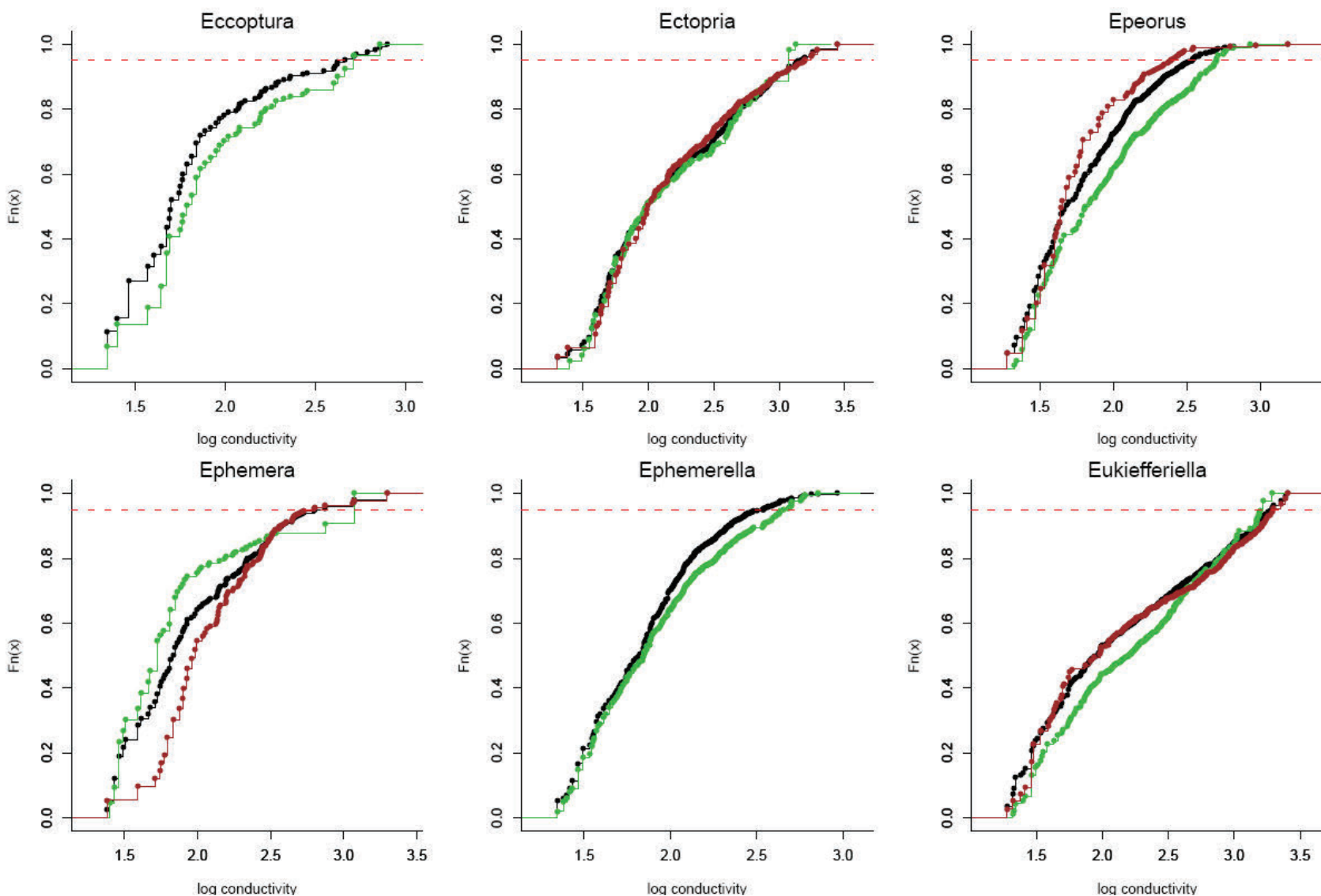


**Figure D-2. Cumulative distribution functions of observation probabilities weighted by sampling frequency for each genus (continued).**

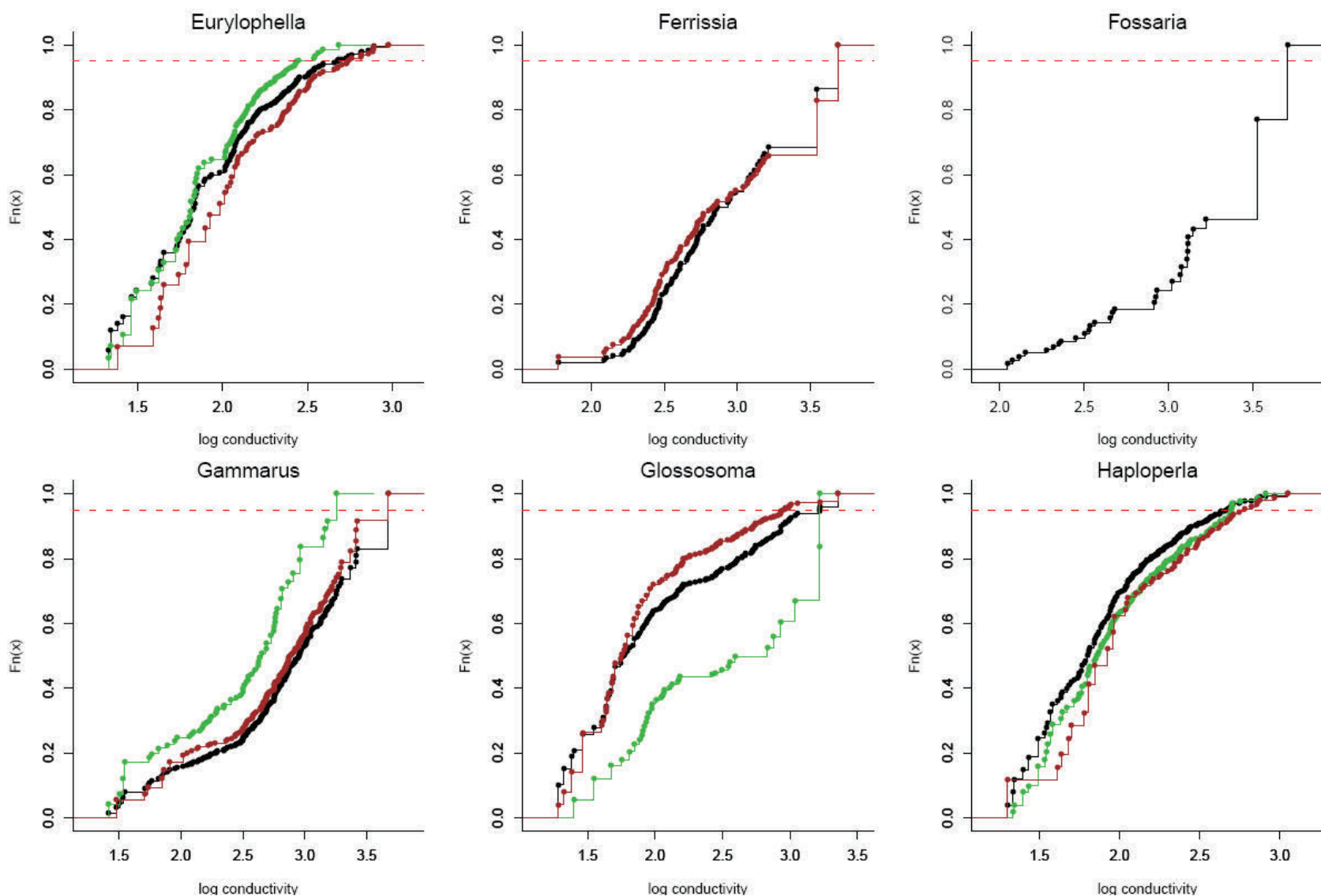


**Figure D-2. Cumulative distribution functions of observation probabilities weighted by sampling frequency for each genus (continued).**

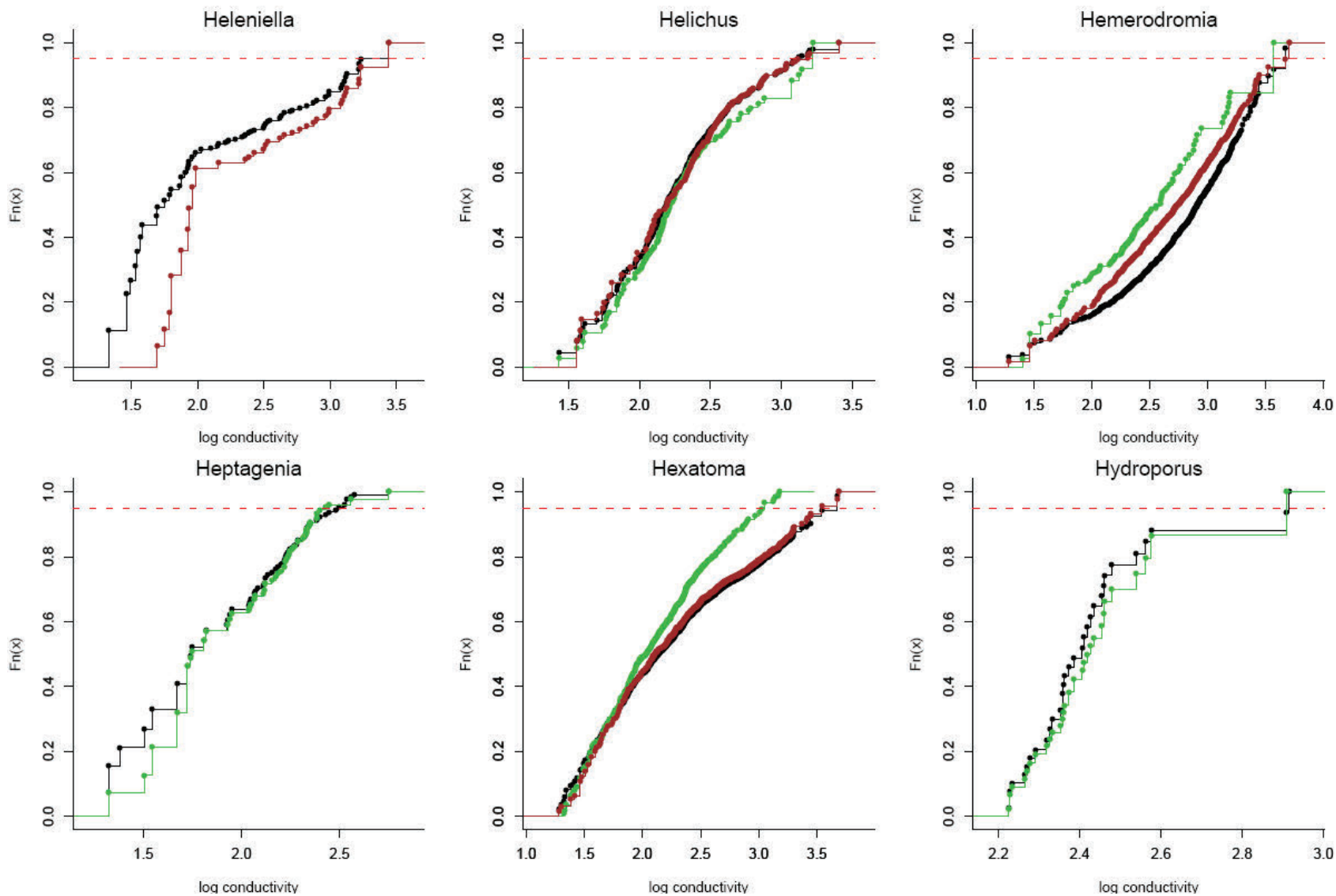




**Figure D-2. Cumulative distribution functions of observation probabilities weighted by sampling frequency for each genus (continued).**

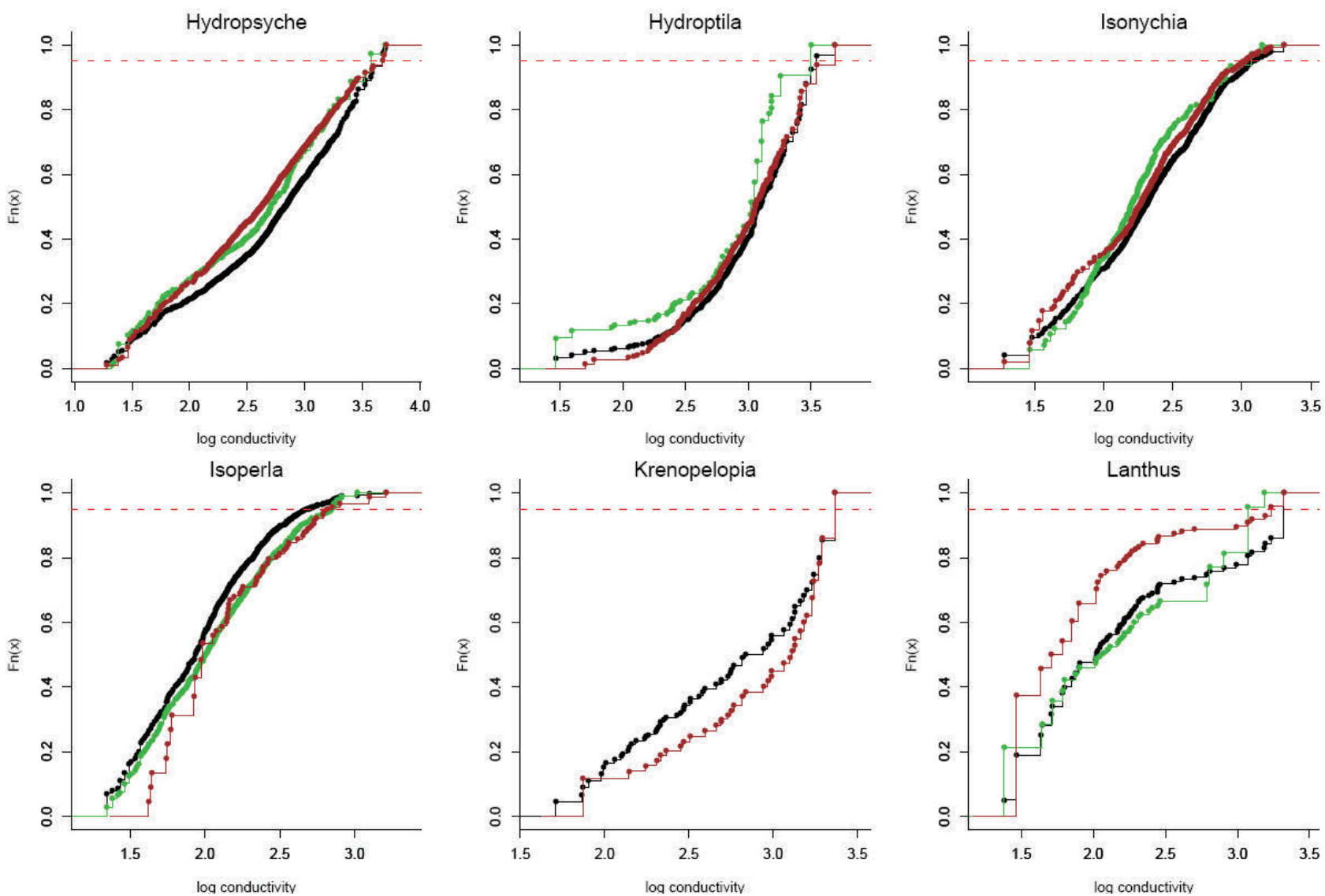


**Figure D-2. Cumulative distribution functions of observation probabilities weighted by sampling frequency for each genus (continued).**

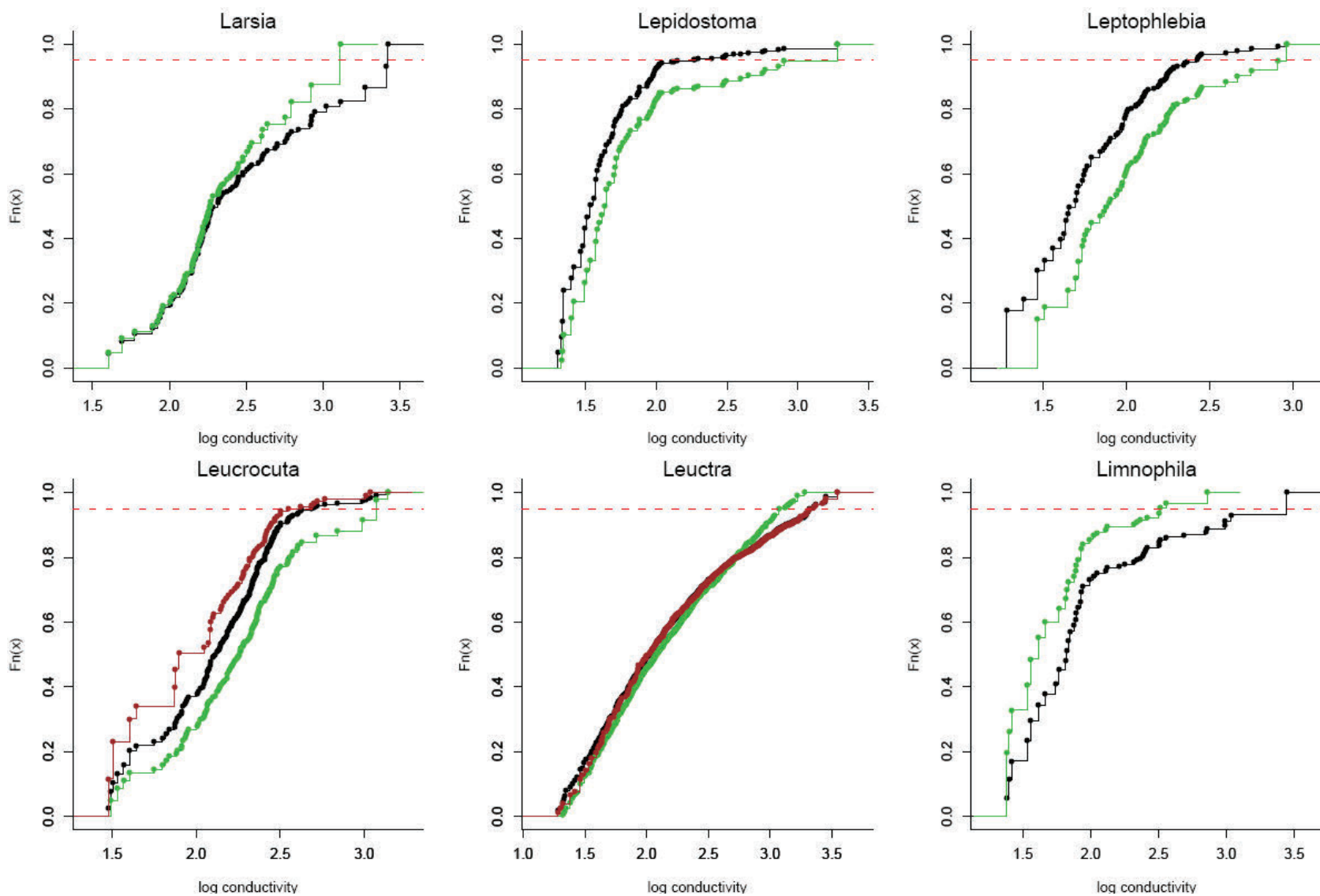


**Figure D-2. Cumulative distribution functions of observation probabilities weighted by sampling frequency for each genus (continued).**

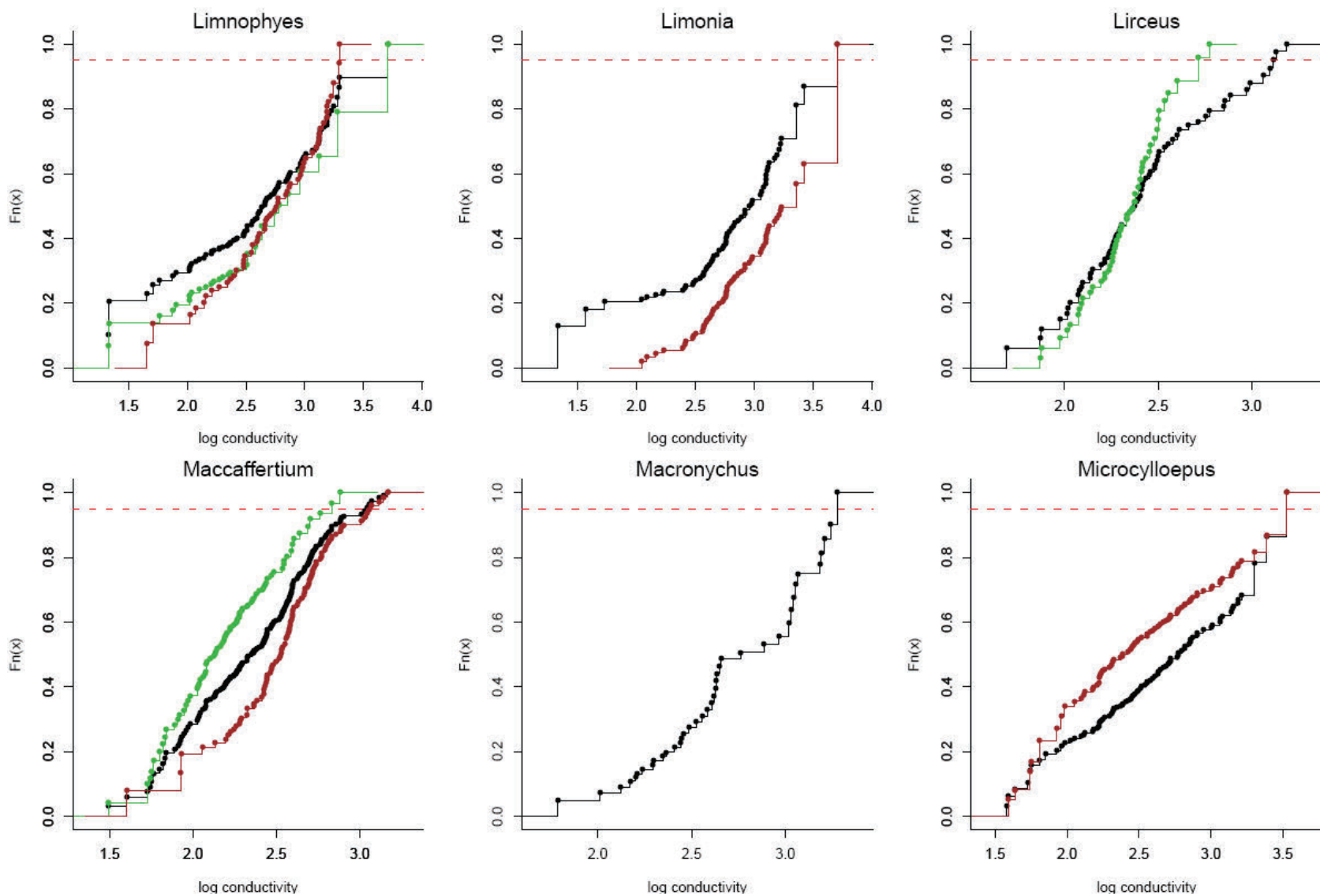




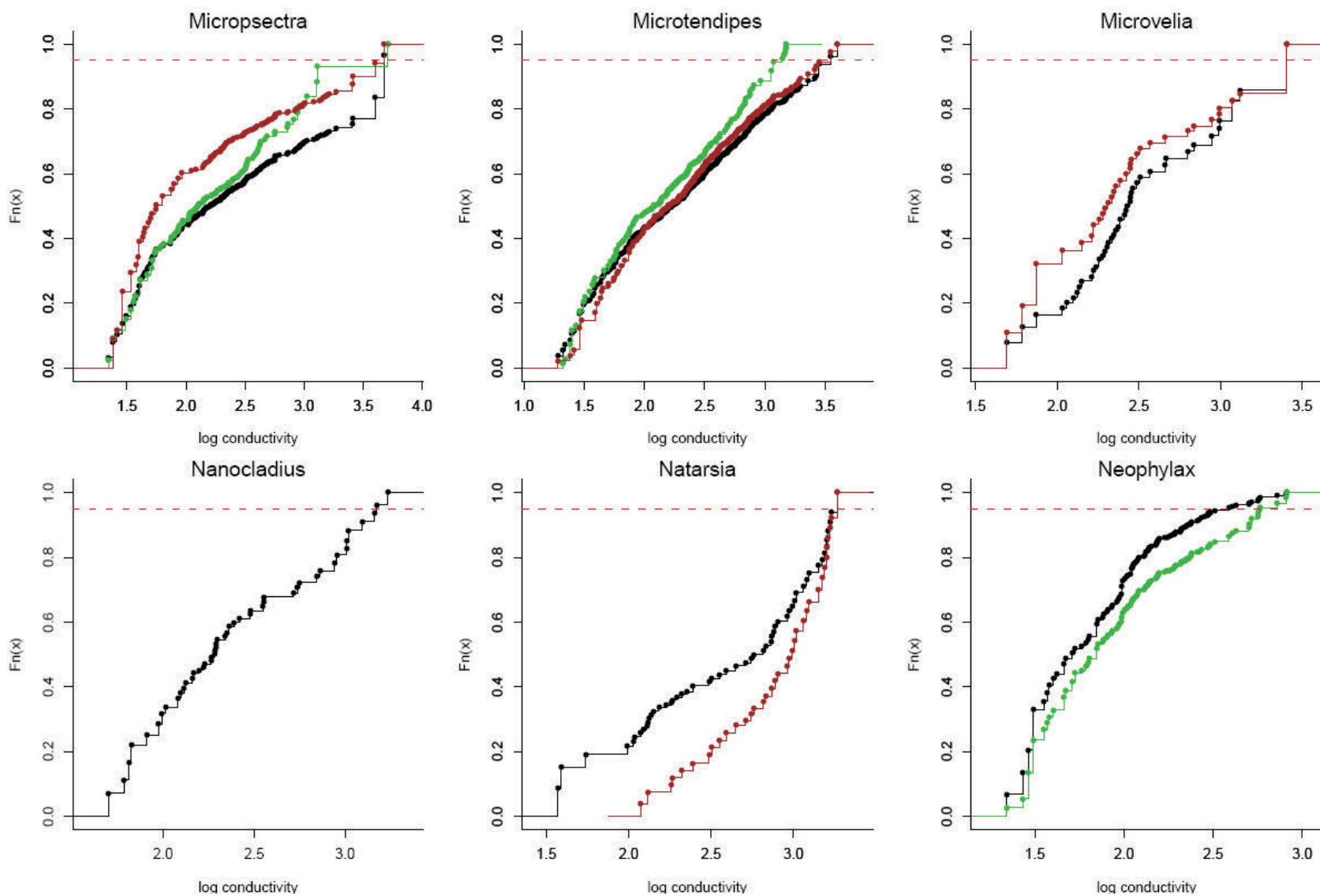
**Figure D-2. Cumulative distribution functions of observation probabilities weighted by sampling frequency for each genus (continued).**



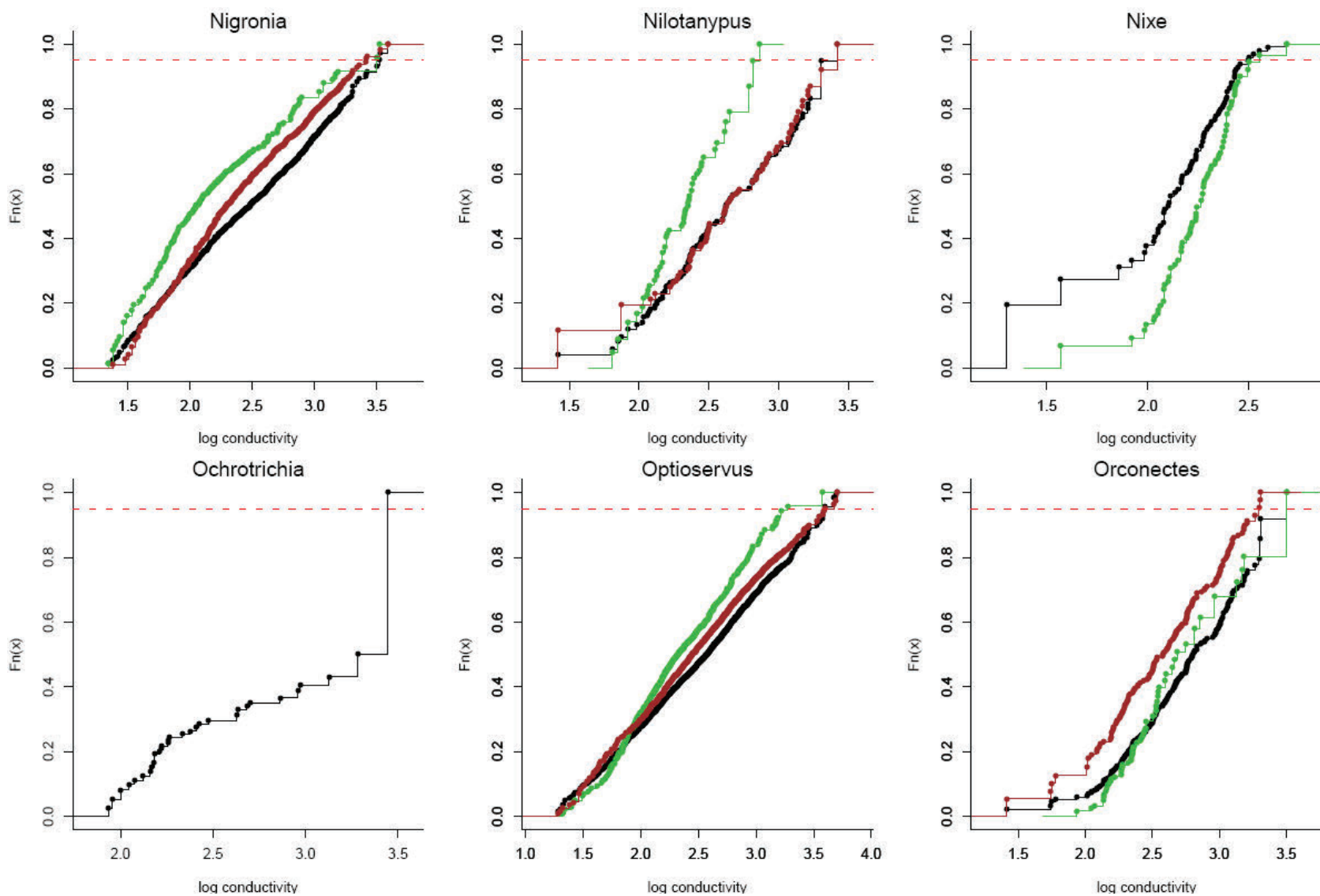
**Figure D-2. Cumulative distribution functions of observation probabilities weighted by sampling frequency for each genus (continued).**



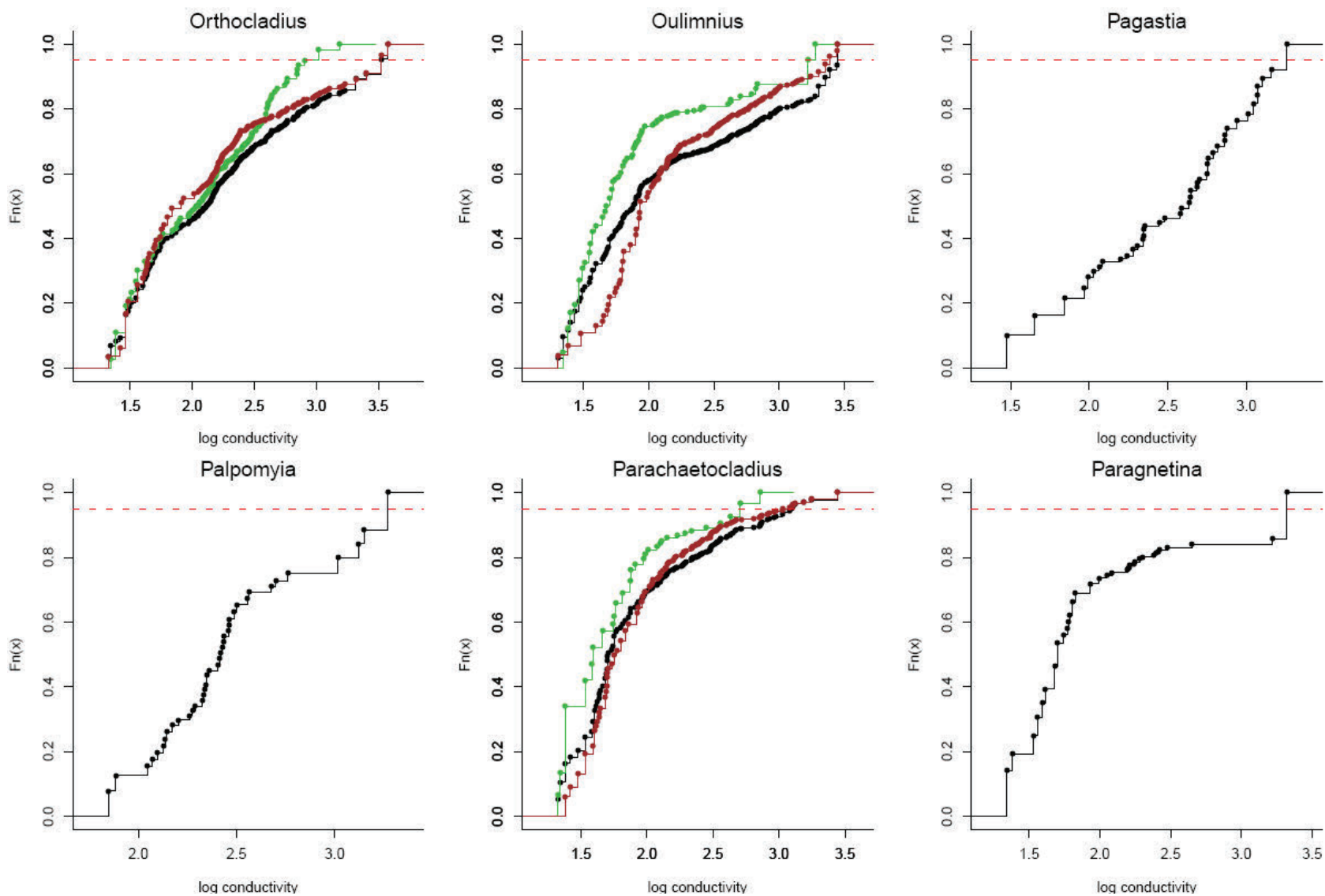
**Figure D-2. Cumulative distribution functions of observation probabilities weighted by sampling frequency for each genus (continued).**



**Figure D-2. Cumulative distribution functions of observation probabilities weighted by sampling frequency for each genus (continued).**

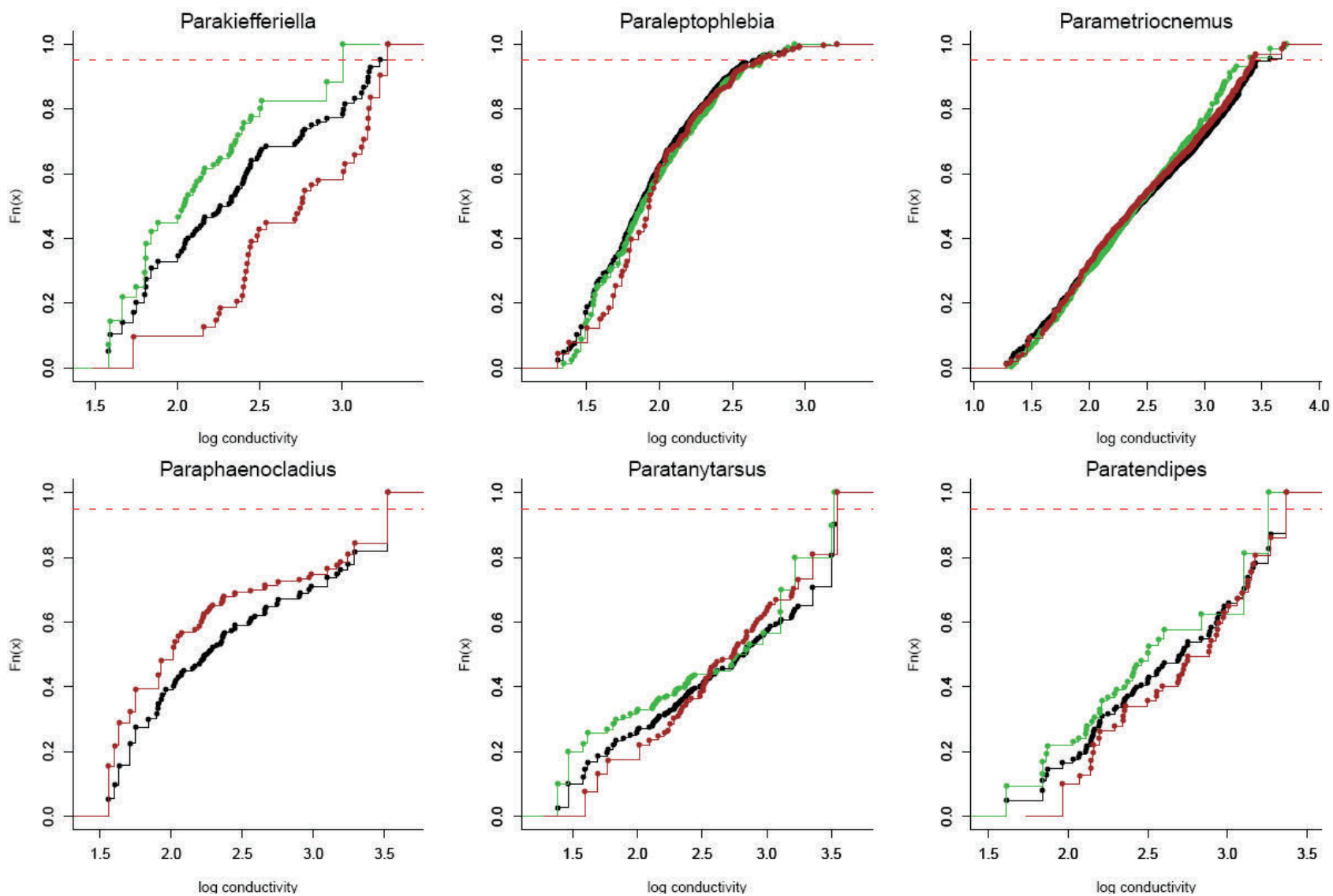


**Figure D-2. Cumulative distribution functions of observation probabilities weighted by sampling frequency for each genus (continued).**

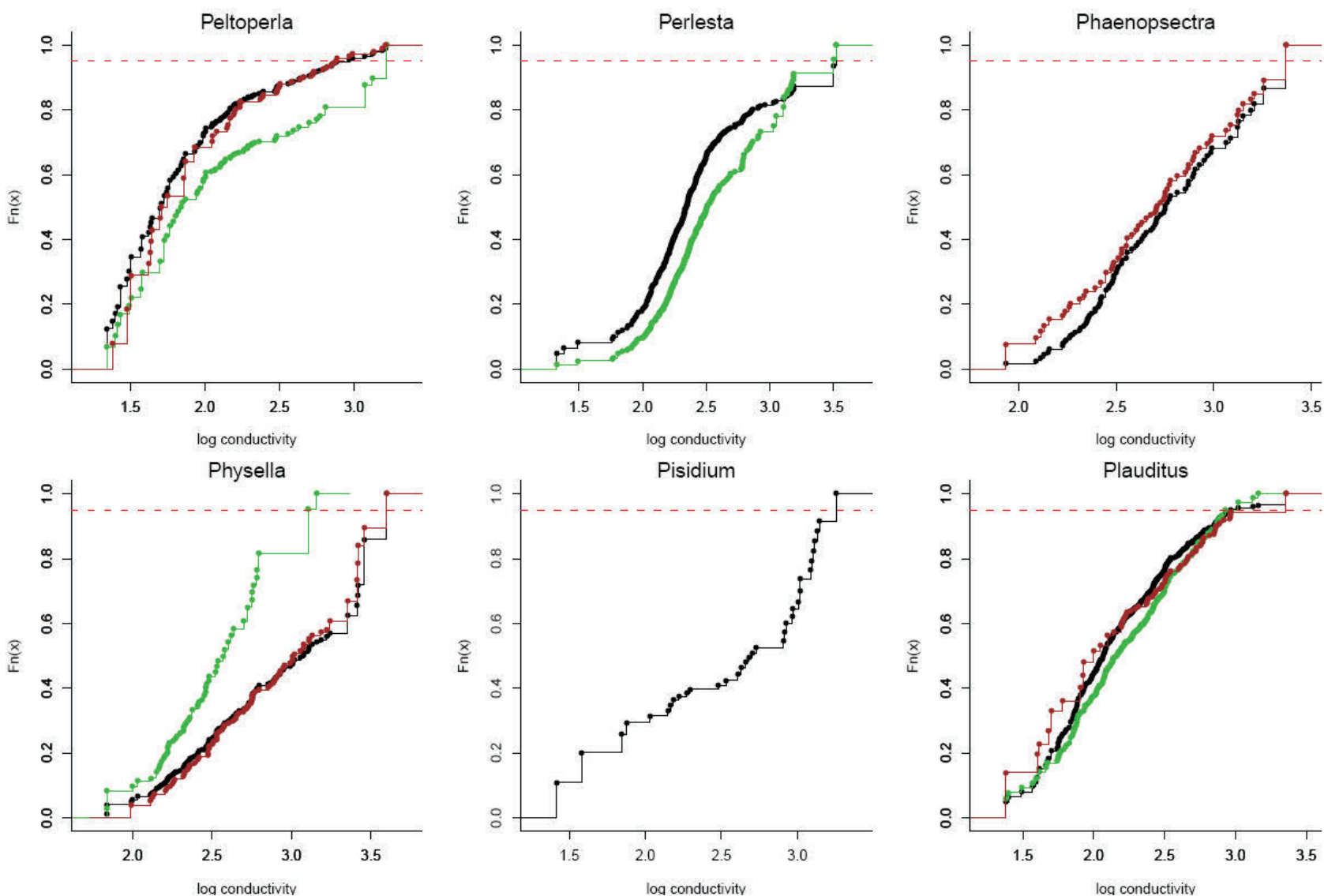


**Figure D-2. Cumulative distribution functions of observation probabilities weighted by sampling frequency for each genus (continued).**



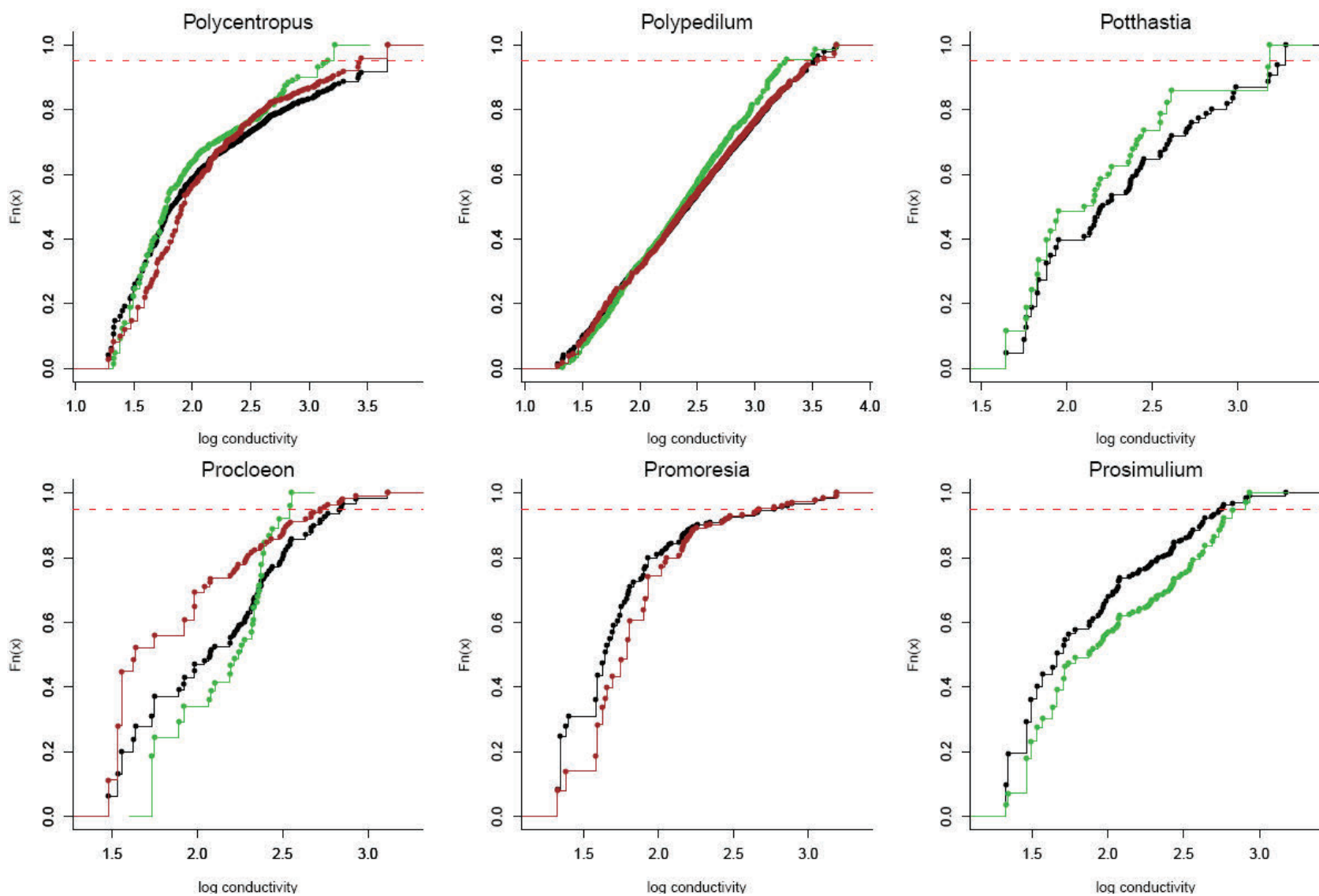


**Figure D-2. Cumulative distribution functions of observation probabilities weighted by sampling frequency for each genus (continued).**

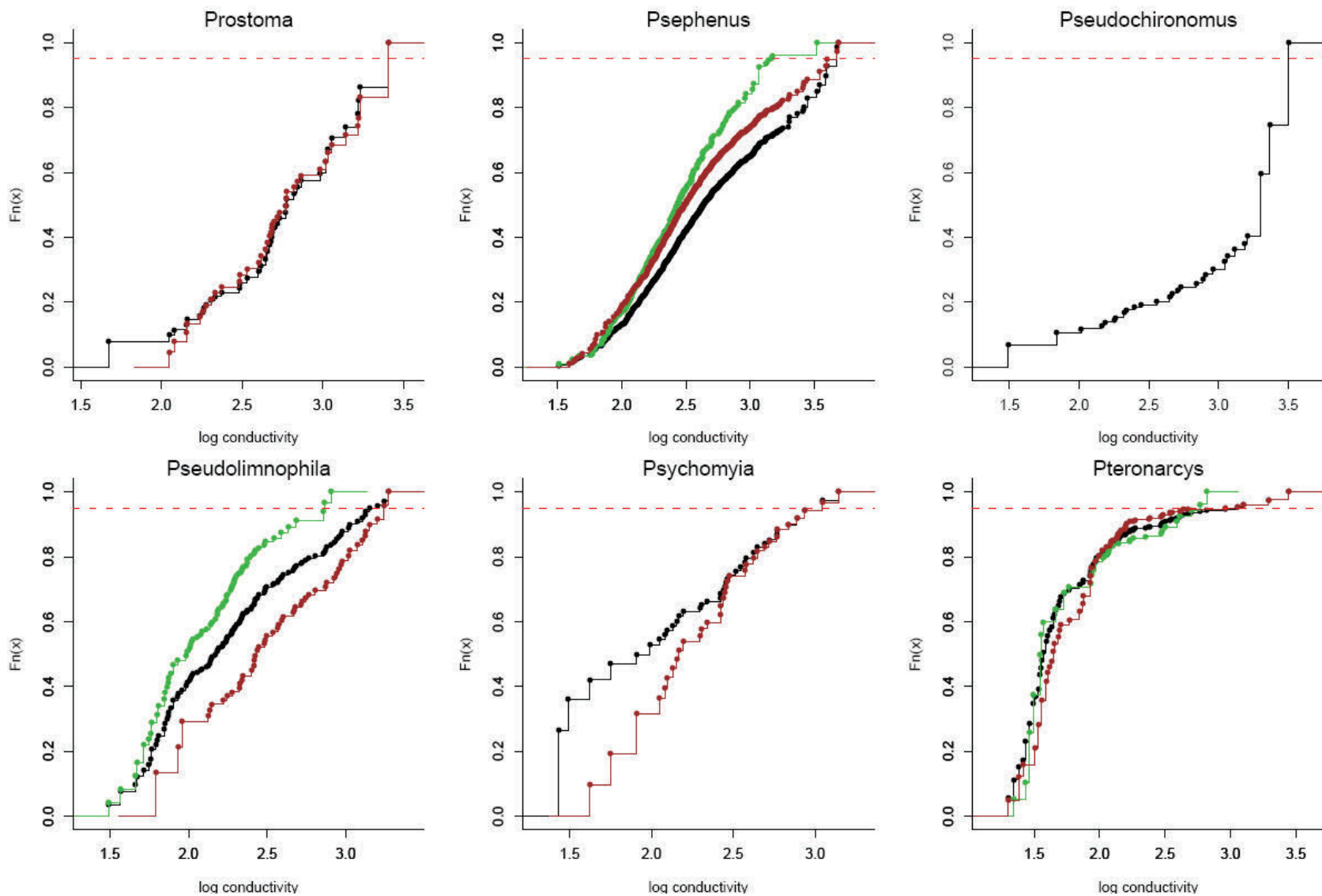


**Figure D-2. Cumulative distribution functions of observation probabilities weighted by sampling frequency for each genus (continued).**

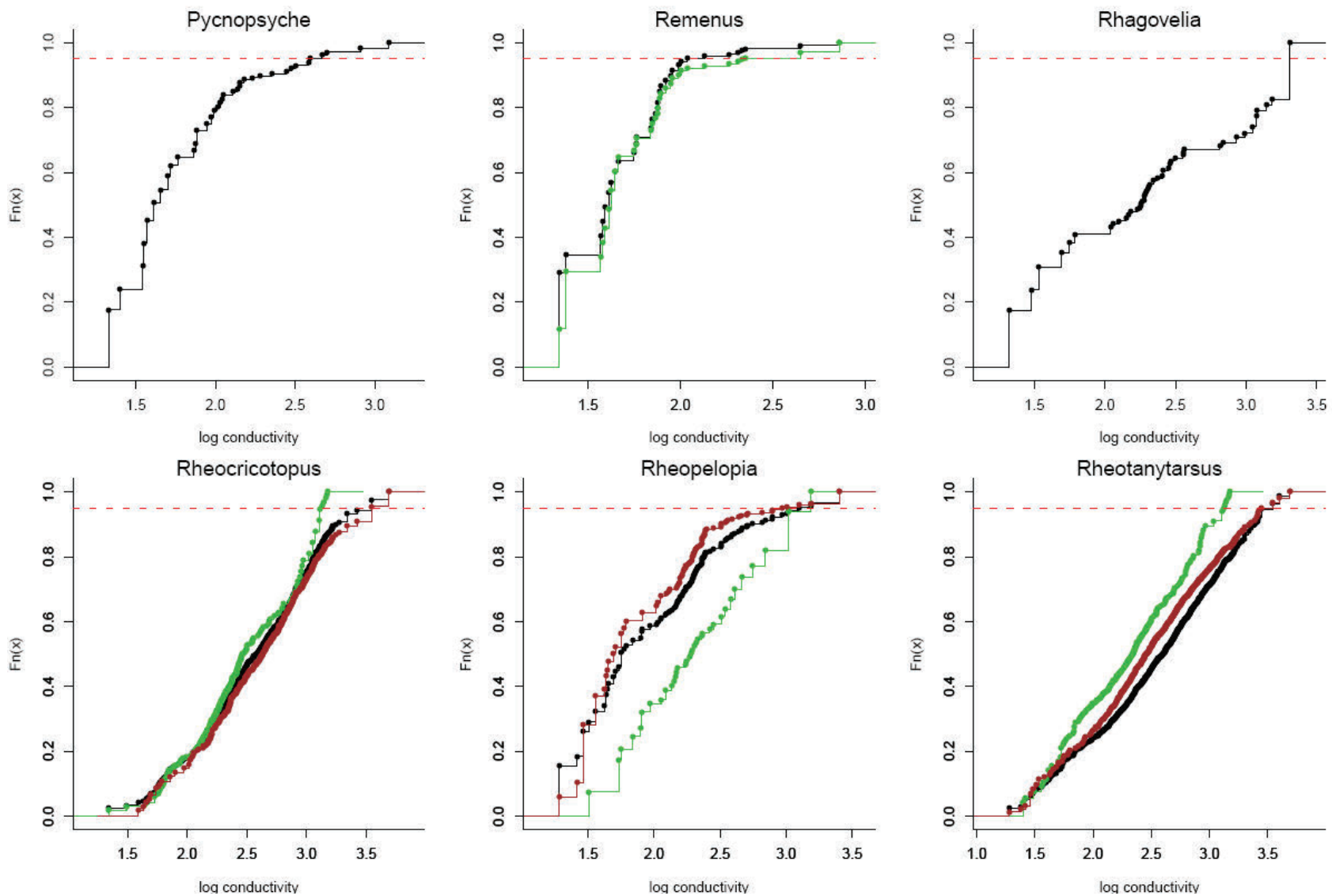




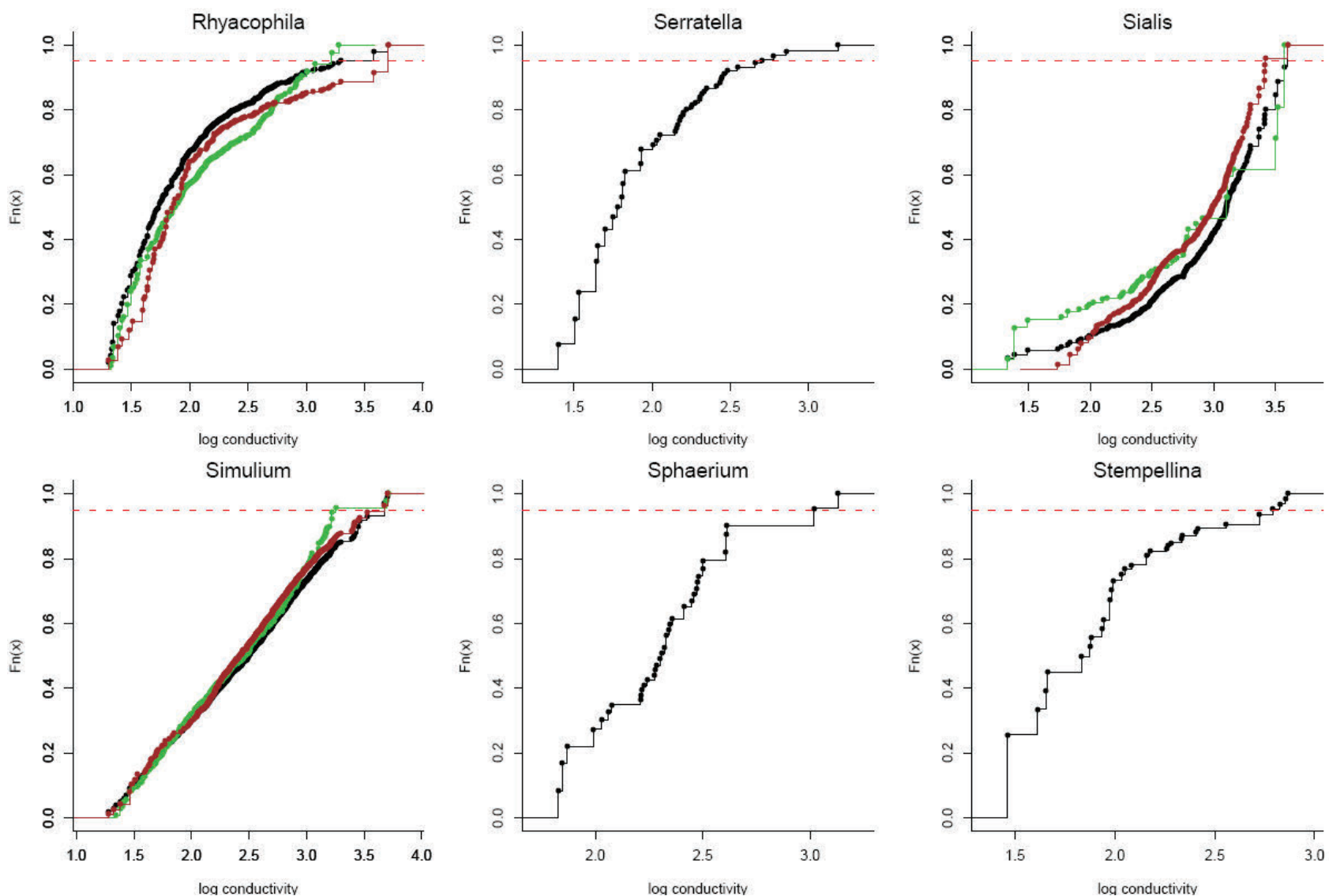
**Figure D-2. Cumulative distribution functions of observation probabilities weighted by sampling frequency for each genus (continued).**



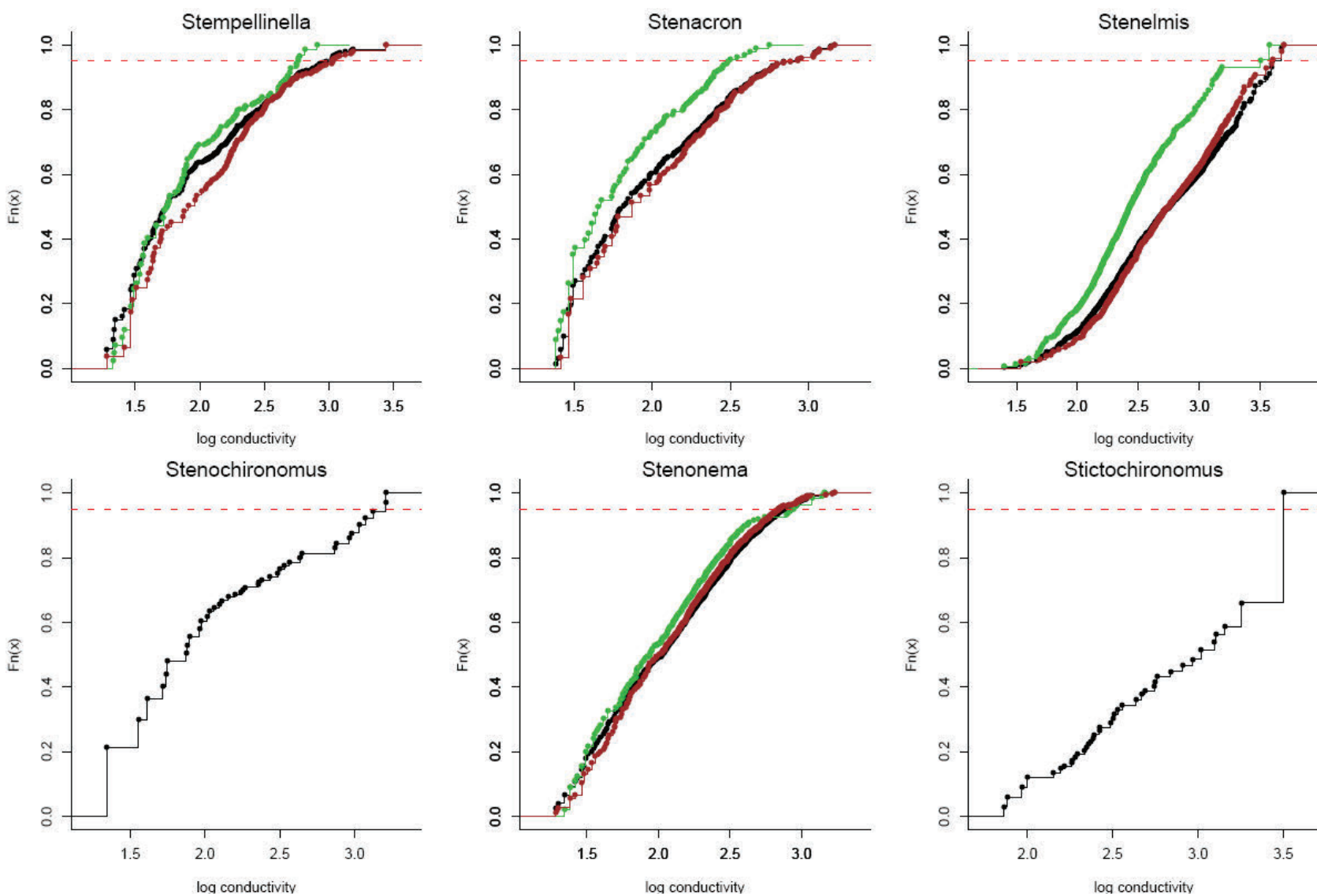
**Figure D-2. Cumulative distribution functions of observation probabilities weighted by sampling frequency for each genus (continued).**



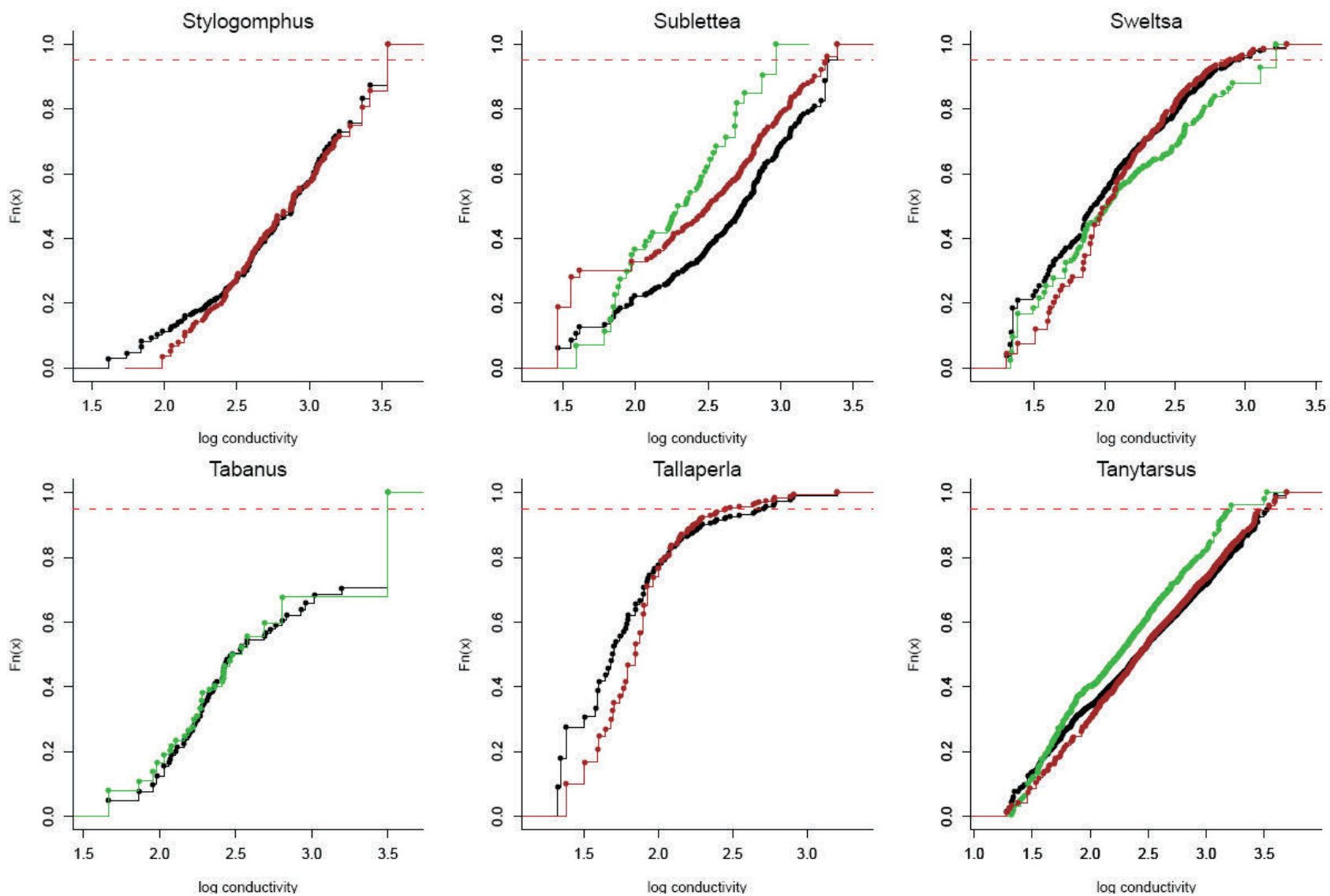
**Figure D-2. Cumulative distribution functions of observation probabilities weighted by sampling frequency for each genus (continued).**



**Figure D-2. Cumulative distribution functions of observation probabilities weighted by sampling frequency for each genus (continued).**

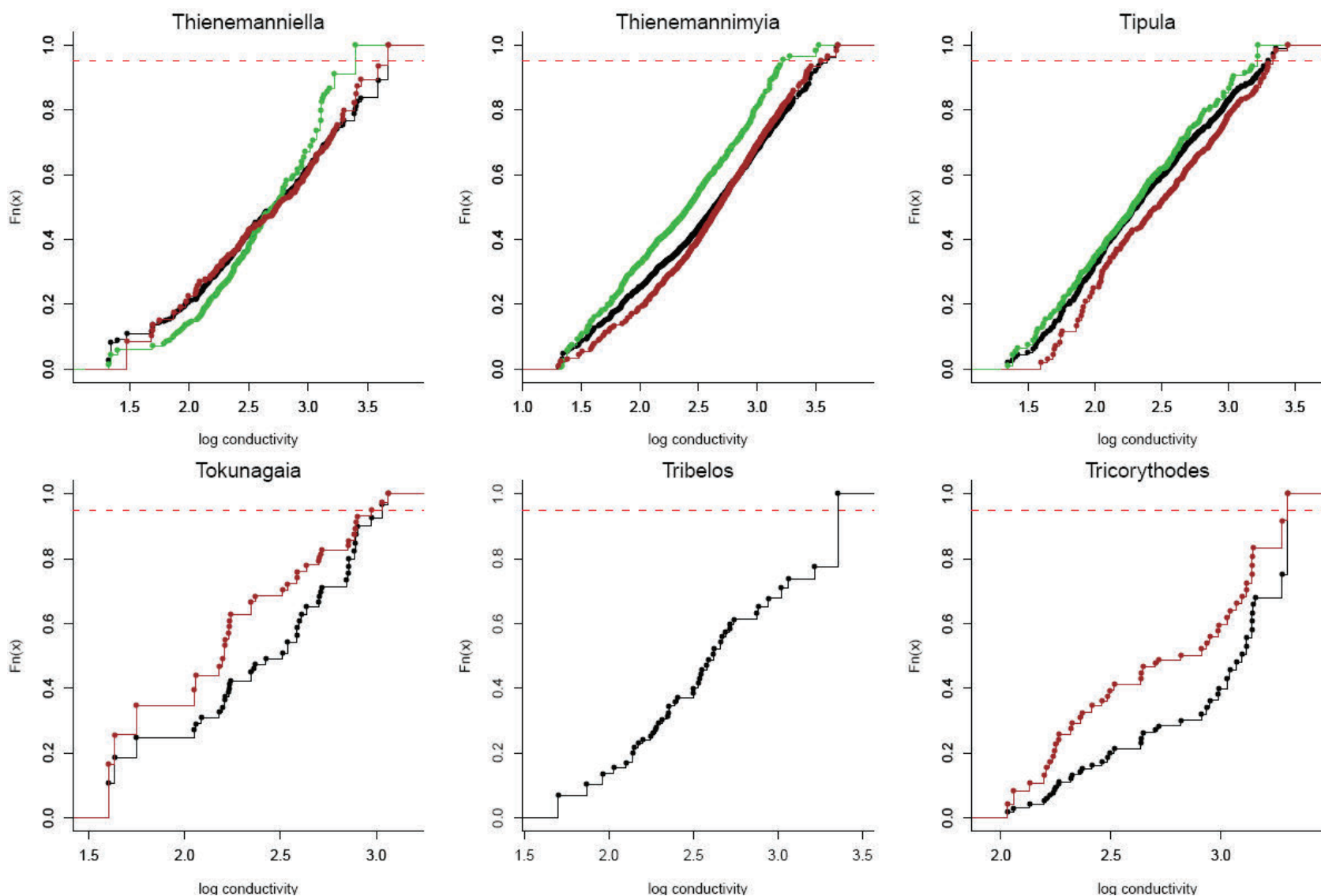


**Figure D-2. Cumulative distribution functions of observation probabilities weighted by sampling frequency for each genus (continued).**

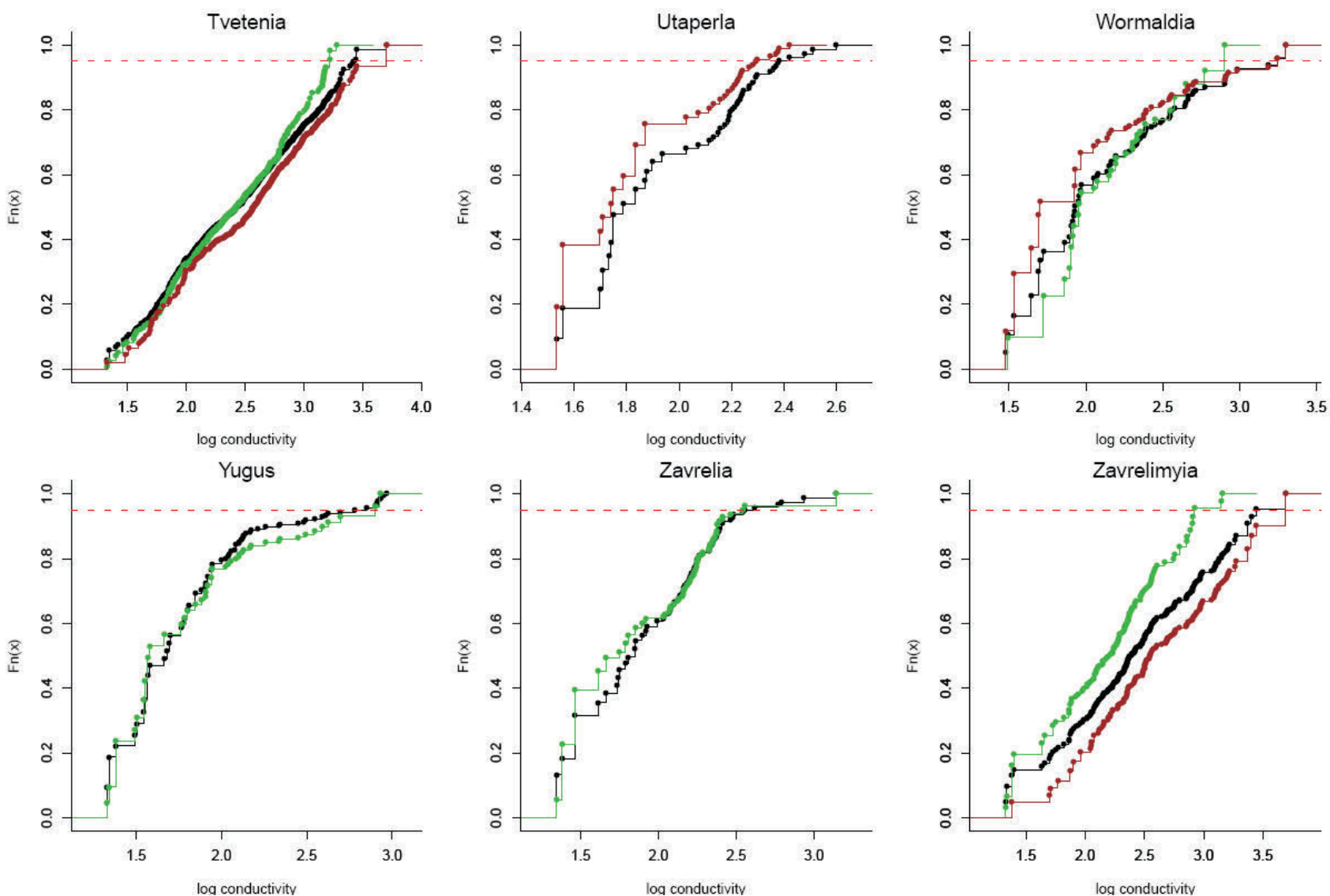


**Figure D-2. Cumulative distribution functions of observation probabilities weighted by sampling frequency for each genus (continued).**





**Figure D-2. Cumulative distribution functions of observation probabilities weighted by sampling frequency for each genus (continued).**



**Figure D-2. Cumulative distribution functions of observation probabilities weighted by sampling frequency for each genus (continued).**



**APPENDIX E**  
**VALIDATION OF METHOD USING FIELD DATA TO DERIVE AMBIENT WATER**  
**QUALITY BENCHMARK FOR CONDUCTIVITY USING KENTUCKY DATA SET**

1 The method for developing the aquatic life benchmark for conductivity was validated by  
2 developing XC<sub>95</sub> and HC<sub>05</sub> values using a data set independently collected by the Kentucky  
3 Division of Water (KDOW) and comparing results with those found using the larger WV  
4 database. Because samples were also drawn from the Central Appalachians (Ecoregion 69) and  
5 Western Allegheny Plateau (Ecoregion 70) the two data sets were expected to give similar  
6 results. Some differences were expected due to the different collection and taxa identification  
7 protocols, shorter sampling window, inclusion of the Southwestern Appalachians  
8 (Ecoregion 68), and the fewer number of samples in the Kentucky data set. Nevertheless, the  
9 HC<sub>05</sub> value was 319 µS/cm for the full Kentucky data set, which is very close to the West  
10 Virginia result.

## 11 12 **E.1. DATA SET SELECTION**

13 The Southwestern Appalachians (68), Central Appalachia (69), and Western Allegheny  
14 Plateau (70) ecoregions were selected for validation, because they are physiographically similar  
15 to Ecoregions 69 and 70 in West Virginia (U.S. EPA, 2000; Omernik, 1987; Woods et al., 1996)  
16 (see Figure E-1). Although the data set is smaller than the West Virginia data set, it was judged  
17 to be large enough for validation of the method. These regions have heavily forested areas as  
18 well as extensive areas developed for coal mining, and, as in West Virginia, conductivity has  
19 been implicated as a cause of biological impairment in the three Kentucky ecoregions. The three  
20 ecoregions were judged to be similar within the state of Kentucky in terms of water quality,  
21 resident biota, and sources of conductivity. Confidence in the quality of reference sites was  
22 relatively high owing to the extensively forested areas of the region. Background conductivity  
23 was estimated from a probability sample from the U.S. EPA Wadeable Stream Assessment  
24 (U.S. EPA, 2006) at the 25<sup>th</sup> percentile using the Spatial Survey Design Package (sp. survey R  
25 package) (Stevens and Olsen, 2004). Background conductivity at the 25<sup>th</sup> percentile was  
26 63 µS/cm for the Southern Appalachians, which includes Ecoregions 68, 69, and 70. When this  
27 value is compared to the 25<sup>th</sup> percentile from a probabilistic subset of the WV data set, it was  
28 similar to the 72 µS/cm value for Ecoregion 69, but much lower than the 153 µS/cm value for  
29 Ecoregion 70.

## 30 31 **E.2. DATA SOURCES**

32 All data used in this study were taken from the Kentucky Division of Water, Water  
33 Quality Branch database (KY EDAS). Chemical, physical, or biological samples were collected  
34 from 274 distinct locations during February to October from 1998–2004 (see Table E-1). Like  
35 WVDEP, the KDOW obtains biological data from both probability biosurvey and targeted  
36 ambient biological monitoring programs. The probability biosurvey program provides a

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condition assessment of the overall biological and water quality conditions for both basin and state levels. Targeted ambient biological monitoring involves intensive data collection efforts for streams of interest as reference or impaired sites or for other reasons. Most sites have been sampled once during February to September. Quality assurance and standard procedures are described by KDOW (2008). All contracted chemical analyses and macroinvertebrate identifications followed internal quality control and quality assurance protocols. This is a well-documented, regulatory database. The quality assurance was judged to be excellent based on the database itself, supporting documentation, and experience of EPA Region 4 personnel.

### **E.3. DATA SET CHARACTERISTICS**

Biological sampling usually occurred once during (February–October) with the KDOW (1998–2004) wadeable sampling protocol. The Kentucky data set was treated in the same way as the WV data used that was used to derive the aquatic life benchmark for conductivity. A sample was excluded from calculations if (1) it lacked a conductivity measurement, (2) the organisms were not identified to the genus level, or (3) the pH was low. Repeat biological samples from the same location at the same time (or within a month) were excluded, but samples collected in different months/years were not excluded from the data set. These repeat biological samples from different years were retained and represented about 8% of the samples. All samples were from wadeable streams. No sites with high chloride and low sulfate were identified or removed from the Kentucky data set. We evaluated the effects of spring benthic invertebrate emergence, seasonal differences in temperature and conductivities by partitioning the data set into spring (February–June) and summer (July–October) subsets. Eighty-one percent of the 95 genera used to develop the SSD for Kentucky also occurred in the WV SSD. This indicates that sensitive genera still exist in both states. Genera from both states were judged to be similarly susceptible to the effects of conductivity after exploratory analysis. Conductivity ranged from 16 to 2,390  $\mu\text{S}/\text{cm}$  for the Kentucky data set and 15 to 11,646  $\mu\text{S}/\text{cm}$  for the WV data set.

In the Kentucky database, 365 benthic invertebrate genera were identified.  $\text{XC}_{95}$  values were not calculated for genera that occurred at <30 sampling sites and therefore, these genera were not used to generate the SSD. Genera that did not occur at reference sites in West Virginia were excluded from the SSD. Of the 365 genera collected, 95 occurred in at least 30 sampling locations in Ecoregions 68, 69, and 70 (see Table E-4). Of the genera occurring in 30 or more samples, all genera occurred in all three ecoregions.

KDOW samples benthic macroinvertebrates using methods similar to WVDEP (KDOW, 2008). KDOW collects 4–0.5  $\text{m}^2$  kick samples in riffle/run habitat and composites them to yield

a 1 m<sup>2</sup> sample. KDOW also supplements collections with multi-habitat qualitative sampling. However, for consistency, these qualitative sampling data were not used in model construction, only the riffle/run samples. Another notable difference in the WVDEP and KDOW methods is that KDOW picks the entire sample in the laboratory, as opposed to WVDEP's fixed-count of 200 organisms. KDOW follows similar field and laboratory quality assurance methods as WVDEP.

#### E.4. CONCLUSIONS

Despite the differences in method and in location, the HC<sub>05</sub> was similar: 319 µS/cm for Kentucky compared to 297 µS/cm for West Virginia (see Figures E-2 and E-3, Table E-2). The 95% confidence bounds for the Kentucky data set value are 180 µS/cm and 439 µS/cm which overlap with the West Virginia data set confidence bounds of 225 µS/cm and 305 µS/c. Genera that exhibited a decreasing occurrence with increasing conductivity were among those with the lowest XC<sub>95</sub> values in both States. Table E-3 shows the 10 lowest XC<sub>95</sub> values for both West Virginia and Kentucky samples. The 5<sup>th</sup> percentile occurs near genus 7 for West Virginia samples and genus 5 for Kentucky samples. Table E-4 lists the genera used to construct the SSD from the Kentucky sample and their XC<sub>95</sub> values.

Based on the similar results, we judged the method to be robust. The same aquatic life benchmark appears to be applicable to West Virginia and Kentucky streams in Ecoregions 68, 69, and 70.

#### REFERENCES

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1 Woods, AJ; Omernik, JM; Brown, DD; et al. (1996) Level III and IV ecoregions of Pennsylvania and the Blue  
2 Ridge Mountains, the Ridge and Valley, and the Central Appalachians of Virginia, West Virginia, and Maryland.  
3 U.S. Environmental Protection Agency, National Health and Environmental Effects Research Laboratory, Corvallis,  
4 OR. EPA/600R-96/077. 50 pp.

5

**Table E-1. Number of samples with reported genera and conductivity.**  
Number of samples is presented for each month, ecoregion, and database.

Region	Month												Total
	1	2	3	4	5	6	7	8	9	10	11	12	
68				10		6	18	2	3				39
69		7	14	44	16	16	42	18					182
70			9	21	2	17	21			10			70
													291

**Table E-2. HC<sub>05</sub> values for Kentucky and West Virginia**

Kentucky	HC <sub>05</sub>		West Virginia	HC <sub>05</sub>
February–October	319 $\mu$ S/cm		March–October	297 $\mu$ S/cm
February–June	397 $\mu$ S/cm		March–June	322 $\mu$ S/cm
July–October	641 $\mu$ S/cm		July–October	479 $\mu$ S/cm

**Table E-3. Comparison of the sensitive genera and XC<sub>95</sub> values**

WV			KY		
Rank	Genus	XC <sub>95</sub>	Rank	Genus	XC <sub>95</sub>
1	Remenus	101	1	Lepidostoma	132
2	Lepidostoma	109	2	Cinygmula	161
3	Cinygmula	224	3	Wormaldia	161
4	Leptophlebia	224	4	Dolophilodes	317
5	Alloperla	228	5	Drunella	320
6	Utaperla	240	6	Epeorus	324
7	Drunella	294	7	Neophylax	324
8	Pycnopsyche	299	8	Oulimnius	378
9	Ephemerella	302	9	Paraleptophlebia	400
10	Heptagenia	313	10	Ephemerella	467

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**Table E-4. Extirpation concentration and sample size from Kentucky data set.** Highlighted genera are not found at WV reference sites. For a genus with a decreasing capture probability with increasing conductivity, the XC<sub>95</sub> is reported directly. If the genus did not occur at the higher conductivity levels, it is reported as a greater than or equal to value ( $\geq$ ). Genera with increasing capture probability with increasing conductivity are reported as greater than ( $>$ ).

Genus	Both		Spring		Summer	
	XC <sub>95</sub>	N	XC <sub>95</sub>	N	XC <sub>95</sub>	N
1 Ablabesmyia	>1,410	43			879	30
2 Acentrella	$\geq$ 618	98	762	67	626	31
3 Acroneuria	$\geq$ 703	105	926	56	703	49
4 Ameletus	$\geq$ 507	69	762	68		
5 Amphinemura	$\geq$ 1,287	107	1,980	105		
6 Ancyronyx	$\geq$ 841	30				
7 Antocha	$\geq$ 958	49				
8 Argia	>1,410	51			950	34
9 Atherix	>1,650	61			2,000	48
10 Baetis	>1,410	170	1,410	79	1,176	91
11 Boyeria	$\geq$ 1,410	92	1,410	36	879	56
12 Caenis	>1,410	85	1,410	35	2,340	50
13 Calopteryx	>1,980	35				
14 Cambarus	$\geq$ 1,132	157	1,163	95	841	62
15 Ceratopsyche	>1,580	102	1,980	34	1,203	68
16 Cheumatopsyche	>1,630	230	1,980	106		
17 Chimarra	>2,000	90	2,260	34	2,000	56
18 Chironomus	>2,340	31				
19 Cinygmula	161	39	183	39		
20 Corbicula	>1,863	84			1,863	60
21 Corydalus	>1,650	121	1,480	33	2,000	88
22 Cricotopus	>2,000	98	1,980	44	2,340	54
23 Diamesa	>1,980	54	1,980	43		

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**Table E-4. Extirpation concentration and sample size from Kentucky data set (continued)**

Genus	Both		Spring		Summer	
	XC <sub>95</sub>	N	XC <sub>95</sub>	N	XC <sub>95</sub>	N
24 Dineutus	879	45			841	33
25 Diplectro	≥958	102	1,228	76		
26 Diploperla	≥702	35	1,157	34		
27 Dolophilodes	317	31				
28 Drunella	320	37	762	35		
29 Dubiraphia	>1,650	86			1,650	65
30 Eccoptura	≥1,228	31				
31 Eclipidrilus	>1,322	92	1,271	47	934	45
32 Ectopria	≥561	66	505	40		
33 Elimia	≥879	33				
34 Ellagma	894	31				
35 Epeorus	324	65	324	59		
36 Ephemera	561	42				
37 Ephemerella	467	70	485	67		
38 Eukiefferiella	>1,650	54	2,260	38		
39 Eurylophella	≥505	84	526	67		
40 Gomphus	≥1,047	36				
41 Haploperla	485	37	485	32		
42 Helichus	≥1,050	147	1,520	80	1,132	67
43 Hemerodromia	>2,000	123	2,260	50	2,000	73
44 Hexatoma	≥1,069	105	762	62	2,000	43
45 Hydropsyche	>1,650	160	1,980	66	2,000	94
46 Hydroptila	>1,863	58			1,863	41
47 Isonychia	≥1,580	132	894	38	1,863	94
48 Isoperla	≥1,176	80	1,157	77		
49 Lanthus	1,520	34				

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**Table E-4. Extirpation concentration and sample size from Kentucky data set (continued)**

Genus		Both		Spring		Summer	
		XC <sub>95</sub>	N	XC <sub>95</sub>	N	XC <sub>95</sub>	N
50	Lepidostoma	132	30				
51	Leucrocuta	≥703	45				
52	Leuctra	≥1,113	131	889	91	2,000	40
53	Lirceus	958	35				
54	Macronychus	≥1,650	54			1,863	41
55	Microtendipes	≥675	58			805	32
56	Natarsia	>1,630	45				
57	Neophylax	324	73	431	67		
58	Nigronia	≥1,203	153	1,113	72	1,203	81
59	Oecetis	≥2,000	31				
60	Optioservus	>1,560	178	1,410	70		
61	Orconectes	>1,302	115	1,287	41	1,277	74
62	Orthocladius	>1,480	49	1,480	39		
63	Oulimnius	378	31				
64	Paraleptophlebia	400	76	762	54		
65	Parametriocnemus	>1,630	184	1,980	111	2,000	73
66	Peltoperla	≥1,520	37				
67	Perlesta	≥1,287	51	1,520	33		
68	Physella	≥2,260	52				
69	Plauditus	≥703	55				
70	Polycentropus	570	82	635	43	570	39
71	Polypedilum	≥1,247	157	1,271	69	950	88
72	Procloeon	≥802	42			768	34
73	Prosimulium	≥958	53	401	46		
74	Psephenus	≥738	111	762	59	879	52
75	Pseudocloeon	855	36				

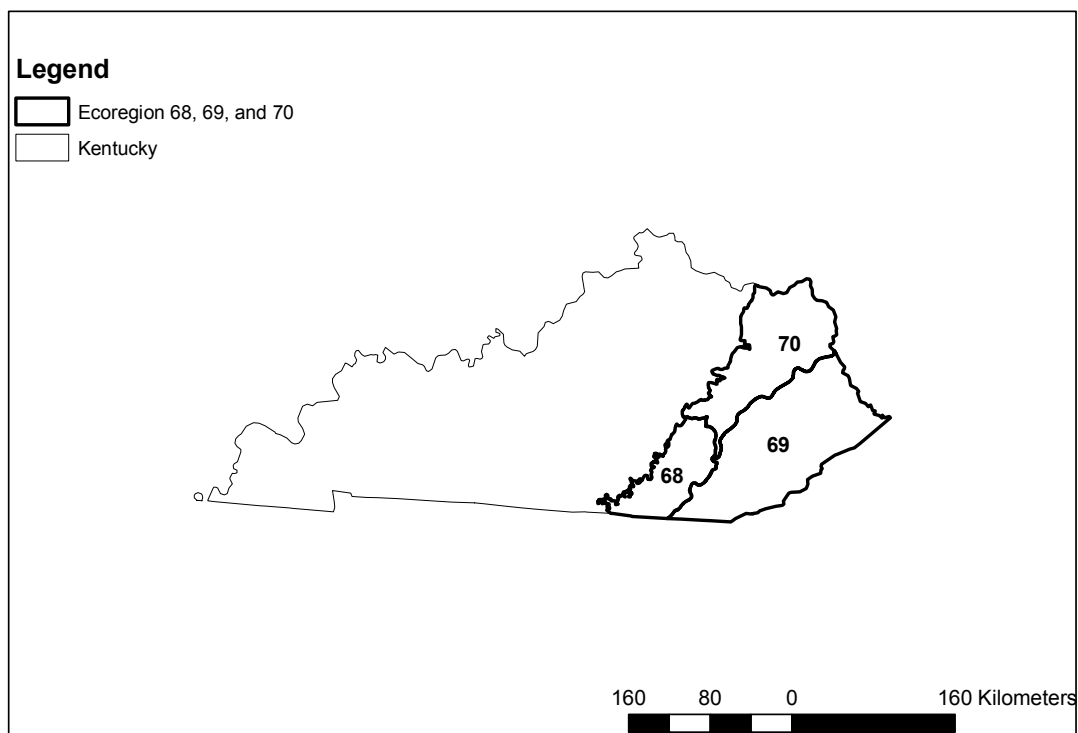
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**Table E-4. Extirpation concentration and sample size from Kentucky data set (continued)**

Genus		Both		Spring		Summer	
		XC <sub>95</sub>	N	XC <sub>95</sub>	N	XC <sub>95</sub>	N
76	Pseudolimnophila	≥1,050	39				
77	Pycnopsyche	≥802	64	889	45		
78	Rheocricotopus	≥1,163	51				
79	Rheotanytarsus	>1,580	115	1,113	36	1,863	79
80	Rhyacophila	≥565	94	820	74		
81	Sialis	>1,287	63	1,980	32	891	31
82	Simulium	>1,580	179	1,410	92	1,863	87
83	Stenacron	879	90	762	37	879	53
84	Stenelmis	≥1,520	168	1,480	81	1,863	87
85	Stenochironomus	≥802	35				
86	Stenonema	≥993	178	658	68		
87	Stylogomphus	>1,863	89	1,480	40	1,863	49
88	Sweltsa	507	55	435	39		
89	Tanytarsus	≥1,287	118	1,163	54	1,863	64
90	Thienemannimyia	≥1,630	139	1,410	71	2,000	68
91	Tipula	>,630	150	1,980	106	2,340	44
92	Triaenodes	841	31				
93	Tricorythodes	>,000	48			2,340	44
94	Tvetenia	>,203	46				
95	Wormaldia	161	38	1,980	34		

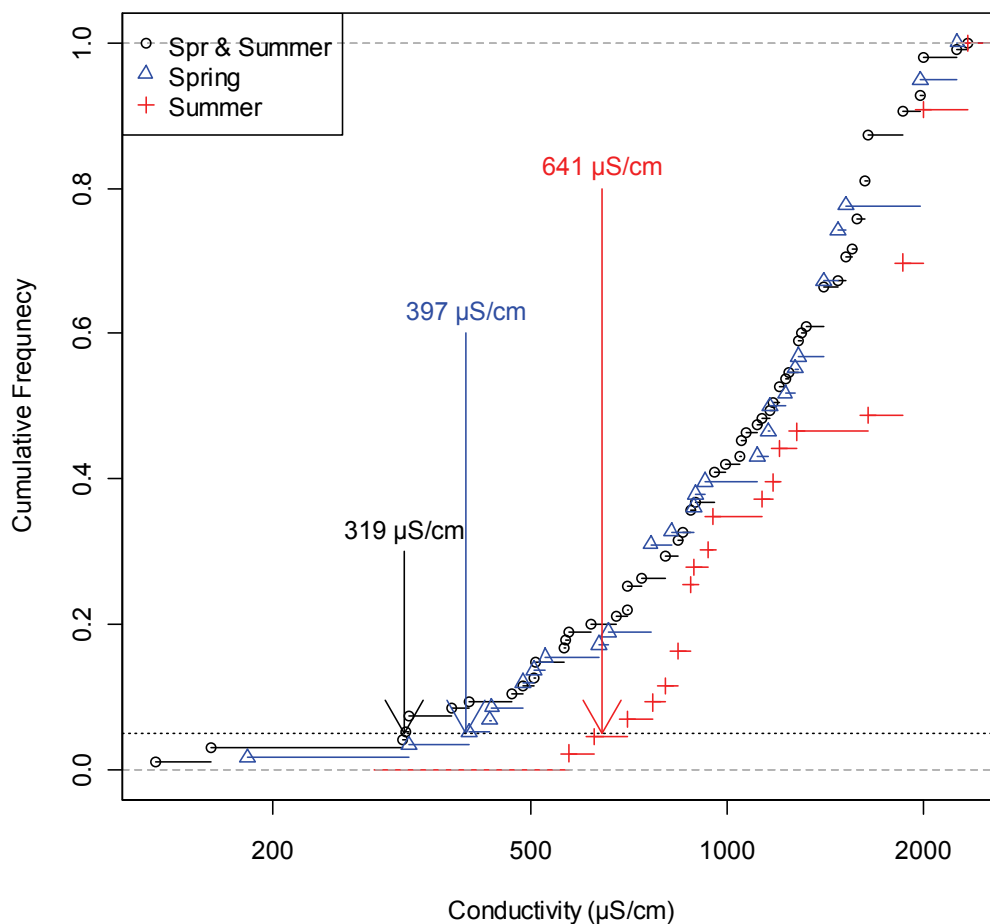
XC<sub>95</sub> = 95<sup>th</sup> percentile extirpation concentration reported as μS/cm; NA = not applicable because it never occurs at WVDEP reference locations; Both = February through October; Spring = Sampled February through June; Summer = July through October; Empty cells indicates fewer than 30 occurrences during that season.

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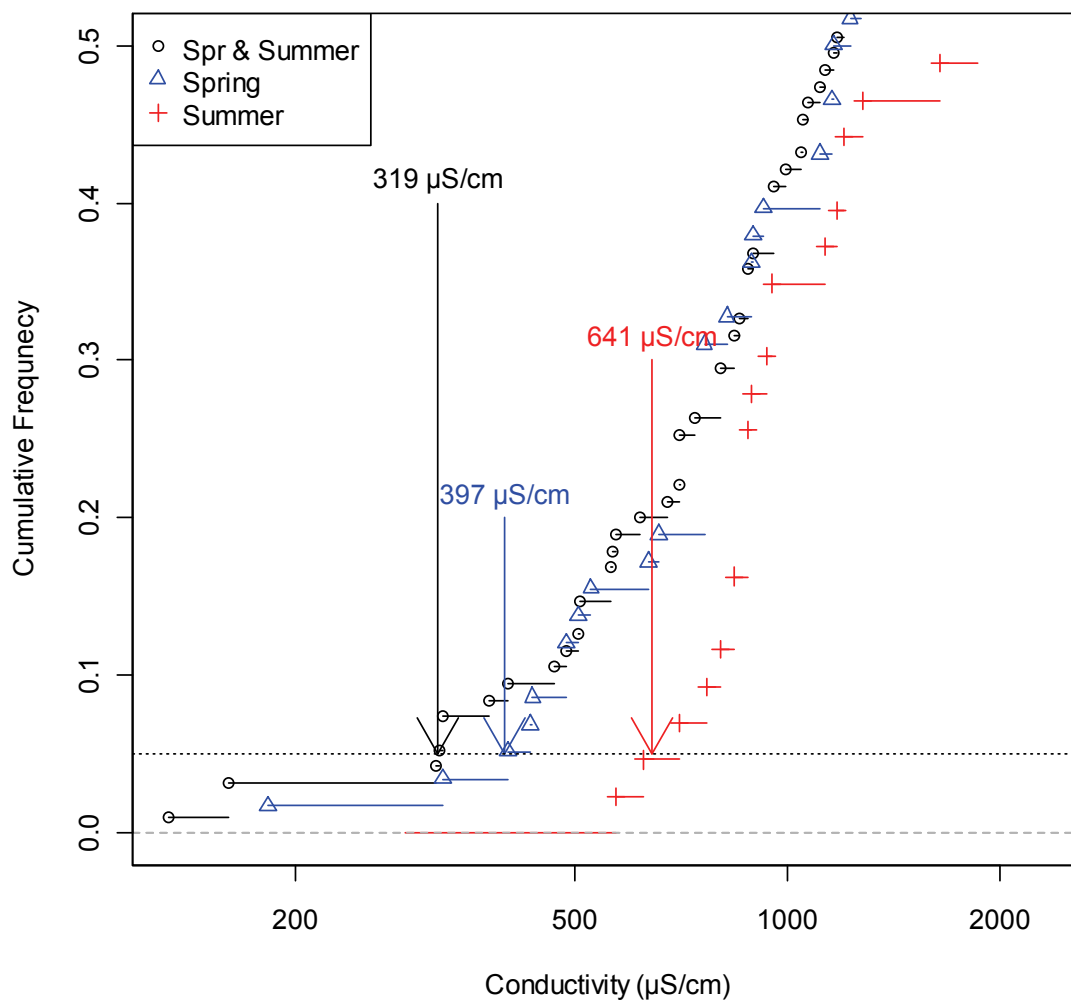


**Figure E-1. Location of Southern Appalachia (68), Central Appalachia (69), and Allegheny Plateau (70).**

Data source: State outlines from the U.S. EPA Base Map Shapefile Omernik Level III Ecoregions from National Atlas (NationalAtlas.gov), projection: NAD 1983 UTM 17 N. Map made December 21, 2009, by M. McManus.



**Figure E-2. The species sensitivity distributions for all year (February through October [black circles], February through June [blue triangles], and July through October [red crosses +]).** Ninety-five genera are included in SSD using the all year data set. The  $HC_{05}$  is the conductivity at the intercept of the CDF with the horizontal line at the 5<sup>th</sup> percentile. For all year, it is 319  $\mu\text{S/cm}$  with 95% confidence bounds at 180  $\mu\text{S/cm}$  and 439  $\mu\text{S/cm}$ .



**Figure E-3. Species sensitivity distribution for all year (black circles), spring (blue triangles), and summer (red crosses +).** Only the lower half genera are shown to better discriminate the points in the left side of the distribution.

**APPENDIX F**  
**DATA SOURCES AND METHODS OF LANDUSE/LAND COVER ANALYSIS USED**  
**TO DEVELOP EVIDENCE OF SOURCES OF HIGH CONDUCTIVITY WATER**

## F.1. OVERVIEW

Analysis of land use and cover was used to determine if there was a source of high conductivity, to assess if land use was associated with conductivity levels, and to confirm the relative proportion of ions associated with land use and cover types reported in the literature. This information was used as evidence of preceding causation in the causal assessment described in Appendix A of this report. A strategy used in this analysis was to limit the watersheds to  $<20 \text{ km}^2$  to minimize the number of land use and cover types within a single watershed, thereby providing a clearer signal. However, because the region has a long history of mining, persistent effects of mining were potentially present even when there was no current record of past or present mining activity.

The final data set consisted of 191 small watersheds for which macroinvertebrate samples were identified to genus, water chemistry was available from at least one sampling effort, subwatershed area was  $\leq 20 \text{ km}^2$ , and detailed land cover information was also available. The data set of 191 sites was drawn from 2,151 sites in Ecoregion 69D described in the West Virginia Department of Environmental Protection's (WVDEP) Watershed Assessment Branch Data Base (WABbase). These 191 tributary watersheds were from the Coal, Upper Kanawha, Gauley, and New Rivers. From each watershed, scatter plots for several parameters were generated for eight land cover classifications: open water, agriculture, urban/residential, barren, valley fill, mining, abandoned mine lands, and forested lands.

Although conductivity typically increases with increasing land use (Herlihy et al., 1998), the densities of agricultural and urban land cover are relatively low, and a clear pattern of increasing conductivity and increasing land use is not evident. At relatively low urban land use, the range of conductivity is highly variable. This may be caused by unknown mine drainage, deep mine break-outs, road applications, poor infrastructure condition (e.g., leaking sewers or combined sewers), or other practices. In contrast, there is a clear pattern of increasing conductivity as percent area in valley fill increases and decreasing conductivity with increasing forest cover. Pairs of land use and water quality parameters with moderately strong correlation coefficients ( $r \geq |0.50|$ ) are listed in Table F-1. All other pairs exhibit  $r < |0.50|$  except a few with spurious points or composed of only 2 points from which no evaluations could be made. Biological effects measured as the West Virginia Stream Condition Index (WVSCI) score or the genus level index of most probable stream status (GLIMPSS) score were weakly correlated with percent forest cover and percent valley fill with  $r > |0.30|$ .

## **F.2. GENERAL GEOGRAPHICAL INFORMATION SYSTEMS (GIS) DATA DESCRIPTIONS**

Numerous geographic information system (GIS) data sets are available for the State of West Virginia. One such repository for West Virginia data, the West Virginia GIS Technical Center (<http://wvgis.wvu.edu/data/data.php>), maintains publicly available shapefiles. WVDEP also maintains a publicly available repository of statewide GIS data sets (<http://gis.wvdep.org/>). All relevant GIS metadata are available for the data housed at each repository site. All GIS coverages used in this U.S. EPA study are in universal transverse mercator (UTM) 1983 Zone 17 and the units are in meters. Table F-2 describes some of the publicly available GIS shapefiles that were used as the total daily maximum load (TMDL) land use base files and the beginning point for determining the 191 stations selected for the analyses described in Section F.3, and as the beginning point for the 191 stations land use analysis described in Section F.4.

## **F.3. METHODS**

The analysis for Appendix A proceeded in two steps; (1) selection of the 191 stations and (2) land use analysis of the 191 stations. Section F.3 describes the selection process for selecting the 191 sample stations, while Section F.4 describes the detailed land use evaluation for each of the 191 stations. Figure F-1 depicts the Ecoregion 69D in relation to the West Virginia State boundary and the 8-digit watershed boundaries, while Figure F-2 shows the locations of the 191 stations within Ecoregion 69D.

### **191 Stations Selection Process within Ecoregion 69D with TMDL Land Use**

- All WVDEP WAB stations located within Ecoregion 69D were selected. This generated 2,151 stations.
- The next station reduction occurred by selecting only stations where a macroinvertebrate sample was collected and identified to the genus level. During this selection process, stations had to have both a WVSCI and a GLIMPSS score. At least one chemistry sample must accompany the macroinvertebrate sample from the same station location. This narrowed the available stations to 825.
- To obtain the TMDL associated land use, stations located within the Coal, Upper Kanawha, Gauley, and New River TMDL watersheds were selected. This narrowed the selection to 382 stations.
- Stations were eliminated if detailed land use was not created during the TMDL process. This eliminated 38 stations for a total of 344 stations.
- Next, a station was eliminated if it was located on an undelineated tributary stream that was contained within a larger main stem subwatershed. Failure to remove these would

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1 generate an overestimation of land use from the entire upstream contributing land use and  
2 not simply the land use from the tributary where the sample was actually located. This  
3 eliminated an additional 33 stations for a total of 311 stations.

- 4 • Lastly, the EPA workgroup limited the upstream contributing land use to stations with a  
5 total watershed drainage area  $\leq 20 \text{ km}^2$  (4,942.08 acres). The total remaining stations in  
6 TMDL watersheds within Ecoregion 69D after this last reduction was 191 stations (see  
7 Figure F-2), and the data from these stations were assembled from 1997 to 2007, with the  
8 majority of samples having been collected from 2001 to 2006. EPA workgroup consisted  
9 of scientists from EPA Office of Research and Development and Region 3, contracted  
10 scientists from Tetra Tech Inc., and scientists from the WVDEP.  
11

#### 12 **F.4. LANDUSE MANIPULATIONS**

13 To create the land use for the 191 stations, the original TMDL land uses from the Coal,  
14 Upper Kanawha, Gauley, and New Rivers were used as the starting point. These land uses were  
15 originally created by consolidating the available base land use (Gap Analysis Program [GAP]  
16 2000 or NLCD) into more general categories and then adding more detailed source land use  
17 categories (e.g., mining, oil and gas, roads) from detailed source information. To add these new  
18 land use categories, GIS shapefiles were used to locate sources and assign areas. These areas  
19 were then subtracted from the category they most likely would be attributed to in the original  
20 base land use. For example, a disturbed mine site would likely be classified as barren in GAP, so  
21 any area assigned as mining would be subtracted from barren to keep the total land use area in  
22 the watershed the same. Table F-3 contains the WVDEP TMDL land use categories, the data  
23 source from which the extent of the area and its location were determined, and the base land use  
24 from which any newly created land use categories were subtracted.

25 Because the WVDEP TMDL land use manipulation process has undergone revisions and  
26 enhancements since the initiation of the TMDL program, WVDEP TMDL land use data sets for  
27 the Upper Kanawha, Coal, Gauley, and New Rivers were manipulated to have equivalent land  
28 use when necessary and resulted in the consolidated land use for the 191 sampling stations. The  
29 land use representation used in TMDL development for more recently developed TMDLs is  
30 more detailed than that for TMDLs completed in earlier efforts. Therefore consolidation of the  
31 detailed TMDL land use to seven basic land use categories was necessary. The valley fill GIS  
32 coverage was then incorporated into the TMDL land use by subtracting the valley fill acreage  
33 from Shank (2004) from the mining land use category. If more area was present in the valley fill  
34 coverage than was present in the TMDL mining area for each TMDL subwatershed, the  
35 remainder was subtracted from barren and then forest, respectively. The eight land use  
36 categories calculated for each of the 191 WAB sampling stations used seven categories

consolidated from the TMDL land use (see Table F-3), then included the addition of the valley fill area.

#### **F.5. CORRELATIONS WITH IN STREAM BIOLOGICAL AND WATER QUALITY PARAMETERS**

Spearman rank correlations of eight land use categories with conductivity and ion concentration were calculated (see Table F-1). Individual scatter plots and associated correlation coefficients for conductivity can be found in Appendix A (see Figure A-3). Land use and land cover were arc sine square root transformed to better depict the upper and lower portions of the distribution.

#### **REFERENCES**

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- Shank, M. (2004) Advanced integration of geospatial technologies in mining and reclamation conference, December 7-9, 2004, Atlanta, GA.

**Table F-1. Pairs of land use and water quality parameters with correlations coefficients >0.5 in the land use data set**

<b>Land use</b>	<b>Water quality parameter</b>	<b><i>r</i></b>
Percent Forest	Conductivity	−0.56
	Alkalinity	−0.51
	Hardness	−0.65
	Sulfate	−0.54
	Calcium-total	−0.64
	Magnesium-total	−0.58
Percent Mined Area	Hardness	0.56
	Calcium-total	0.51
	Magnesium-total	0.58
Percent Valley Fill Area	Conductivity	0.65
	Alkalinity	0.50
	Sulfate	0.64
	Calcium-total	0.66
	Magnesium-total	0.66

**Table F-2. Publicly available GIS data used to generate land cover estimates**

<b>Data information</b>	<b>Data description</b>	<b>Source</b>
General sources of land use/land cover information		
West Virginia GIS Technical Center	General West Virginia Universities GIS data repository location	<a href="http://wvgis.wvu.edu/data/data.php">http://wvgis.wvu.edu/data/data.php</a>
WVDEP GIS data sets	General WVDEP's GIS data repository location	<a href="http://gis.wvdep.org/">http://gis.wvdep.org/</a>
Base Land use/land cover		
GAP	GAP land use	<a href="http://wvgis.wvu.edu/data/dataset.php?ID=62">http://wvgis.wvu.edu/data/dataset.php?ID=62</a>
NLCD 2001	NLCD land use	<a href="http://wvgis.wvu.edu/data/dataset.php?ID=269">http://wvgis.wvu.edu/data/dataset.php?ID=269</a>
Other files		
Watershed Boundary Datasets	USGS 8-digit Hydrologic Unit Code boundaries	<a href="http://wvgis.wvu.edu/data/dataset.php?ID=123">http://wvgis.wvu.edu/data/dataset.php?ID=123</a>
NHD Streams	National Hydrography Dataset Streams	<a href="http://wvgis.wvu.edu/data/dataset.php?ID=235">http://wvgis.wvu.edu/data/dataset.php?ID=235</a>
Abandoned Mine Lines (AML-Highwalls) and Polygons (AML Areas)	West Virginia abandoned mine lands coverages. Highwall mine coverage and AML area	<a href="http://wvgis.wvu.edu/data/dataset.php?ID=150">http://wvgis.wvu.edu/data/dataset.php?ID=150</a>
OMR Mining NPDES Permits and Outlets	WVDEP Office of Mining and Reclamation NPDES permit and outlet coverages	<a href="http://gis.wvdep.org/data/omr.html">http://gis.wvdep.org/data/omr.html</a>
Mining related Fills, Southern West Virginia	WVDEP valley fills coverage from 2003	<a href="http://gis.wvdep.org/data/omr.html">http://gis.wvdep.org/data/omr.html</a>
Mining Permit Boundaries	WVDEP Mining permit boundaries	<a href="http://wvgis.wvu.edu/data/dataset.php?ID=149">http://wvgis.wvu.edu/data/dataset.php?ID=149</a>
Roads_Paved	2000 TIGER/Line GIS and WV_Roads shapefiles	<a href="http://wvgis.wvu.edu/data/data.php">http://wvgis.wvu.edu/data/data.php</a>
Roads_Unpaved	2000 TIGER/Line GIS shapefile and digitized from aerial photographs and topographic maps	<a href="http://wvgis.wvu.edu/data/data.php">http://wvgis.wvu.edu/data/data.php</a>

GAP = Gap Analysis Program; GIS = geographic information system; NHD = National Hydrography Dataset; NLCD = National Land Cover Database; NPDES = National Pollutant Discharge Elimination System; OMR = Office of Mine Reclamation; USGS = U.S. Geological Survey; WVDEP = West Virginia Department of Environmental Protection.

*This document is a draft for review purposes only and does not constitute Agency policy.*

**Table F-3. Detailed WV TMDL Land Use Category Derivation and Land Use Derivation used in Appendix A.** Base land use categories highlighted in grey.

Detailed WV TMDL Land Use Category	Data source	Base land use from which New Source Area was subtracted	Land use categories used in scatter plots in Appendix A
Water	Water—base LU coverage	N/A	Water
Wetland	Wetland—base LU coverage	N/A	Water
Forest	Forest—consolidated all forested types from base LU coverage	N/A	Forest
Grassland	Grassland—base LU coverage	N/A	Agriculture
Cropland	Cropland—consolidated all cropland types from base LU coverage	N/A	Agriculture
Urban Pervious	Urban—consolidated urbanized types from base LU coverage	N/A	Urban/residential
Urban Impervious	Urban—consolidated urbanized types from base LU coverage	N/A	Urban/residential
Barren	Barren—base LU coverage	N/A	Barren
Pasture	Source tracking	New area subtracted from Grassland	Agriculture
Paved roads	Roads shapefiles	New area subtracted from Urban Impervious	Urban/residential
Unpaved roads	Roads shapefiles	New area subtracted from Urban Pervious	Urban/residential
Revoked Mining Permits	AML information	New area subtracted from Barren	AML
Abandoned Mine Land	AML shapefile	New area subtracted from Barren	AML
Quarry	Mining shapefile	New area subtracted from Barren	Mining
Highwall	AML shapefile	New area subtracted from Barren	Mining
Oil and Gas	Oil and Gas shapefile	New area subtracted from Barren	Mining

*This document is a draft for review purposes only and does not constitute Agency policy.*

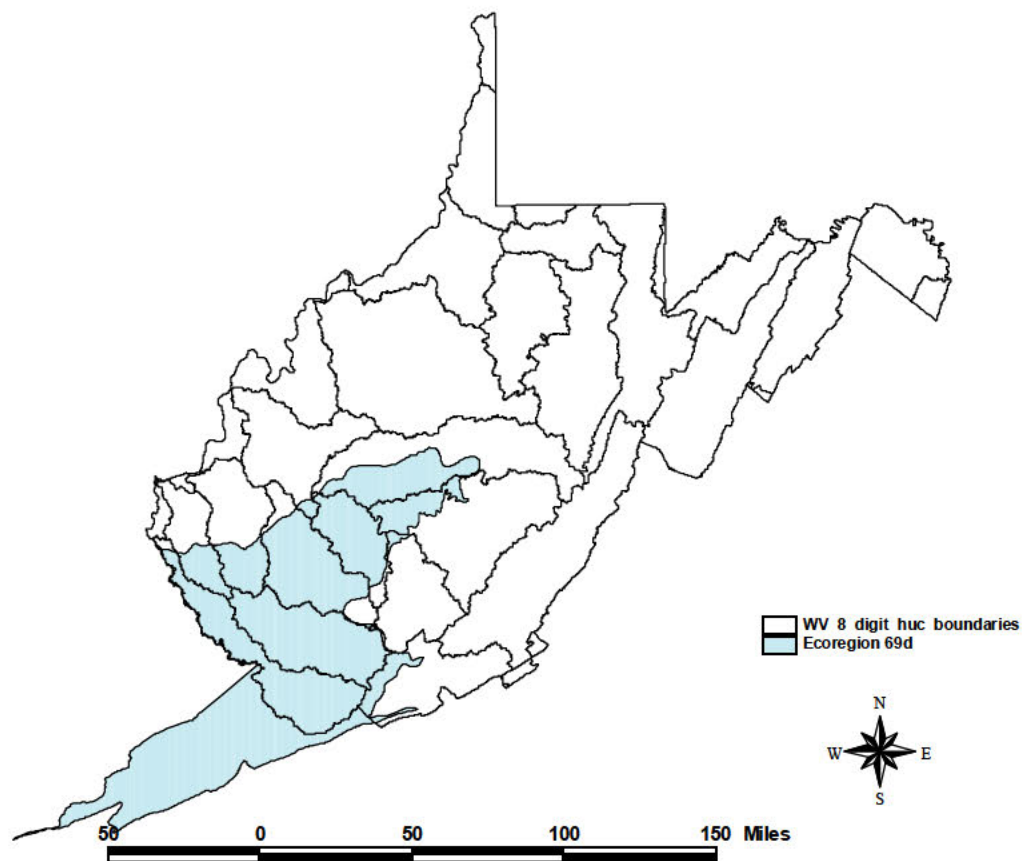
**Table F-3. Detailed WV TMDL Land Use Category Derivation and Land Use Derivation used in Appendix A (continued)**

<b>Detailed WV TMDL Land Use Category</b>	<b>Data source</b>	<b>Base land use from which New Source Area was subtracted</b>	<b>Land use categories used in scatter plots in Appendix A</b>
Surface Mine Water Quality permits	Mining shapefile	New area subtracted from Barren	Mining
Surface Mine Technology permits	Mining shapefile	New area subtracted from Barren	Mining
Comingled mine deep ground gravity discharge	Mining shapefile	New area subtracted from Barren	Mining
Comingled mine deep ground pump discharge	Mining shapefile	New area subtracted from Barren	Mining
Undeveloped surface mine WQ permits	Mining shapefile	New area subtracted from Forest	Mining
Undeveloped surface mine technology permits	Mining shapefile	New area subtracted from Forest	Mining
Undeveloped comingled mine gravity discharge	Mining shapefile	New area subtracted from Forest	Mining
Undeveloped comingled mine pump discharge	Mining shapefile	New area subtracted from Forest	Mining
Burned Forest	Forestry Dept. information	New area subtracted from Forest	Barren
Harvested Forest	Forestry Dept. information	New area subtracted from Forest	Barren
Skid Roads	Forestry Dept. information	New area subtracted from Forest	Barren
TMDL land use considers Valley Fill <sup>a</sup> area as part of the Surface Mine Water Quality and Technology Permit information	WVDEP valley fills coverage from 2003	New area subtracted from Mining, Barren and Forest, as appropriate	Valley fill

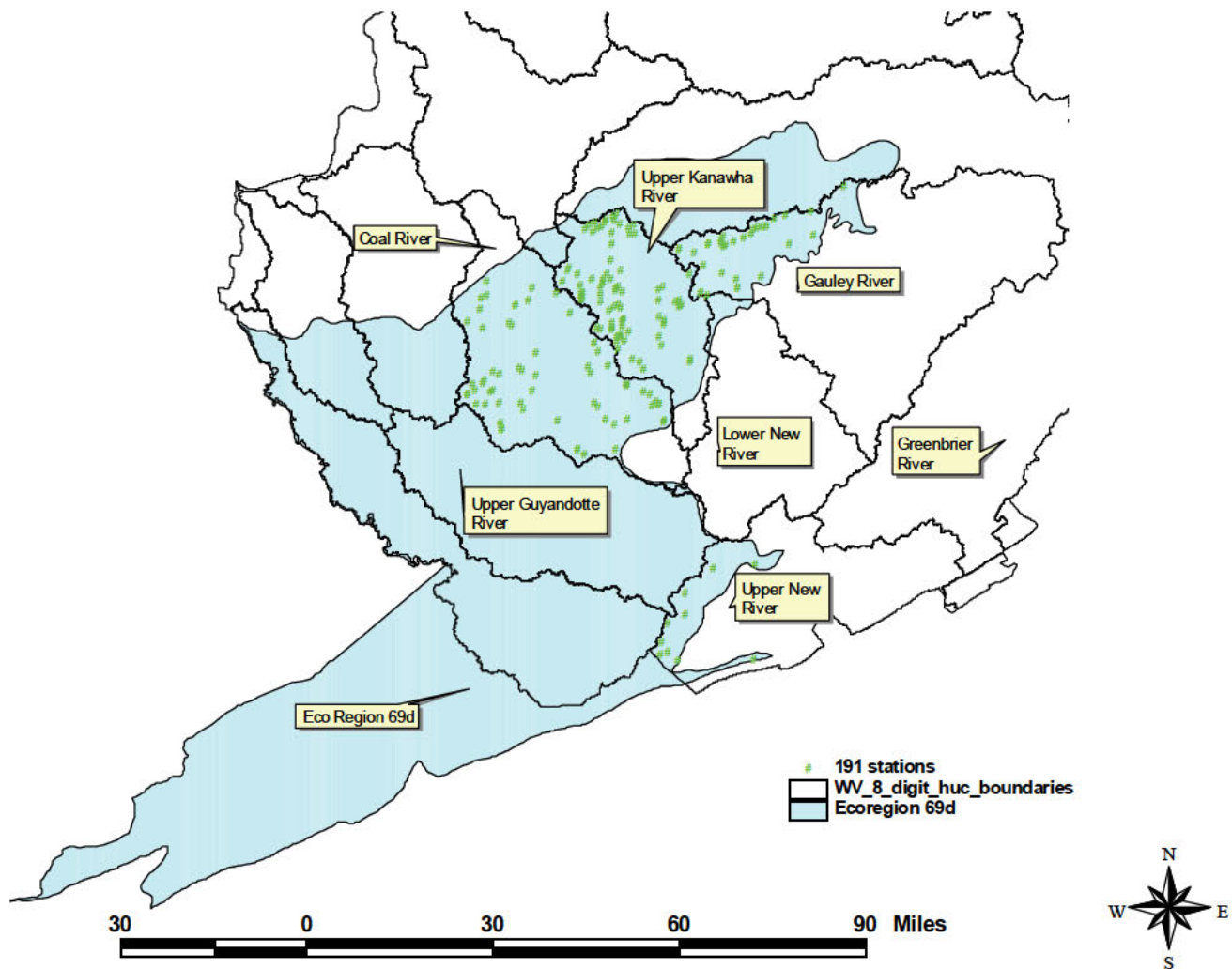
<sup>a</sup>Valley fill land use was not part of the base TMDL land use and was specifically incorporated into the detailed land use analysis during the EPA ion study for the 191 stations. See Table F-2 for the source file.

LU = land use; WQ = water quality.

*This document is a draft for review purposes only and does not constitute Agency policy.*



**Figure F-1. West Virginia 8-digit Hydrologic Unit Code boundaries, Ecoregion 69D.**



**Figure F-2. One hundred ninety-one station locations used in the detailed land use analysis.**



Laura Bachle/DC/USEPA/US

12/09/2010 09:02 AM

To

cc Abu Moulta-Ali, Brian Frazer, Christopher Hunter

bcc

Subject Re: Fw: King Coal Highway/Buffalo Mountain Discussion

(b) (5)

hey are doing this pursuant to 23 CFR 771.30(c), new circumstances or new information.

(b) (5)

I don't have any other updated information from March to now. Here's what I have. Doubtless you guys are more up to speed on what is going on now. Let me know how I can help.



Buffalo Mtn Briefingpaper 2-10-10sds.doc Buffalo Mtn one pg\_020510.doc

Laura

David Evans

We'll need to prepare a fact sheet and email co...

12/08/2010 02:00:28 PM

From: David Evans/DC/USEPA/US  
To: Brian Frazer/DC/USEPA/US@EPA, Abu Moulta-Ali/DC/USEPA/US@EPA, Laura Bachle/DC/USEPA/US@EPA  
Date: 12/08/2010 02:00 PM  
Subject: Fw: King Coal Highway/Buffalo Mountain Discussion

We'll need to prepare a fact sheet and email communications to WO and OA about FHWA's interest in meeting on King Coal Highway. (b) (5)

Dave

David Evans, Director  
Wetlands Division  
Office of Wetlands, Oceans and Watersheds  
(202) 566-0535

----- Forwarded by David Evans/DC/USEPA/US on 12/08/2010 01:58 PM -----

From: David Evans/DC/USEPA/US  
To: <Gerald.Solomon@dot.gov>  
Cc: Laura Bachle/DC/USEPA/US@EPA  
Date: 12/08/2010 01:58 PM  
Subject: RE: King Coal Highway/Buffalo Mountain Discussion

Gerry,

I was out of office last Friday, but had intended to reply to you on Monday. (b) (5)



Look forward to seeing you on meeting planned for Dec. 23rd (first half of the Quarterly OW-FHWA managers meeting).

Dave

David Evans, Director  
Wetlands Division  
Office of Wetlands, Oceans and Watersheds  
(202) 566-0535

---

Dave Thank you for information on King Coal an...

12/03/2010 02:18:58 PM

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From: <Gerald.Solomon@dot.gov>  
To: David Evans/DC/USEPA/US@EPA  
Date: 12/03/2010 02:18 PM  
Subject: RE: King Coal Highway/Buffalo Mountain Discussion

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Dave

Thank you for information on King Coal and VT Circ.

I also want to provide an FHWA update on King Coal. Just prior to receiving Laura's email to schedule a meeting, I received an email from Tom Smith, our WV Division Administrator indicating that King Coal activities associated with CONSOL energy are expected to restart shortly on a permit application.

Through a PPP expected to yield in excess of \$100 million in public benefits, Consol intends to build a section of the roadway as a part of its mining operation. Its operation affects a 5 mile part of a 6.5 mile operationally independent section, that in turn is part of the overall 96 mile total King Coal highway project covered in the original ROD.

FHWA's would be involved in an environmental assessment that looks at a short limited relocation of part of the previously approved alignment. This new alignment and approval would entitle CONSOL to a waiver for returning the mined land to Approximate Original Contour (AOC).

The Corp of Engineers in Huntington, WV will receive a permit application with the FHWA EA covering most of the template for the mining and also assessing the slight changes. The COE is expected to use this information as part of the 404 process, possibly supplementing with additional information specifically needed for 404 purposes.

In order for the process to proceed expeditiously once started, and in order to get EPA's concerns identified as early as possible, Tom asked that FHWA HQ and EPA participate in an on-site meeting in December or January to discuss

the project. His office would make all the arrangements for the meeting and include other federal and state government representatives, as appropriate (COE, WVDOT, and WVDEP). If needed, he is also available to participate in a pre-meeting conference call to address any questions or concerns.


Please advise of your availability.

Gerry Solomon  
Director  
FHWA Office of Project Development and Environmental Review  
1200 New Jersey Ave SE  
Washington DC 20590  
202 366-2037  
gerald.solomon@dot.gov

-----Original Message-----

From: Evans.David@epamail.epa.gov [mailto:Evans.David@epamail.epa.gov]  
Sent: Thursday, December 02, 2010 6:07 PM  
To: Solomon, Gerald (FHWA)  
Cc: Laura Bachle; Brian Frazer  
Subject: Re: King Coal Highway/Buffalo Mountain Discussion

Gerry, look forward to our upcoming discussions. (b) (5)



Dave  
David Evans, Director  
Wetlands Division  
Office of Wetlands, Oceans and Watersheds  
(202) 566-0535  
(202) 725-6415 (cell)

-----Sent from my BlackBerry Wireless Handheld

----- Original Message -----

From: [Gerald.Solomon@dot.gov]  
Sent: 12/02/2010 01:08 PM EST  
To: Laura Bachle  
Cc: <Marlys.Osterhues@dot.gov>; <Patricia.Cazenas@dot.gov>; David Evans; Brian Frazer; Jim Pendergast; Rachel Herbert  
Subject: Re: King Coal Highway/Buffalo Mountain Discussion

Thank you Laura. I appreciate your efforts to get an early meeting on these time sensitive issues. As you know many from my office will be unavailable due to EDC summits until mid December (this week was WA). The week of December 20 may work (Dave indicated he is available on 22nd and 23rd). I am available on those dates. While the sooner the better, others may be out due to holidays. If so, the best dates may be the first week in January - maybe the 4th, 5th, or 6th. When you have other responses, please let me what is decided. In the interim, I am available if you, Dave, or others want to talk about WV, VT, or anything else.

Gerry

----- Original Message -----

From: Bachle.Laura@epamail.epa.gov [mailto:Bachle.Laura@epamail.epa.gov]  
Sent: Tuesday, November 30, 2010 01:37 PM  
To: Solomon, Gerald (FHWA)  
Cc: Osterhues, Marlys (FHWA); Cazenias, Patricia (FHWA);  
Evans.David@epamail.epa.gov <Evans.David@epamail.epa.gov>;  
Frazer.Brian@epamail.epa.gov <Frazer.Brian@epamail.epa.gov>;  
Pendergast.Jim@epamail.epa.gov <Pendergast.Jim@epamail.epa.gov>;  
Herbert.Rachel@epamail.epa.gov <Herbert.Rachel@epamail.epa.gov>  
Subject: RE: King Coal Highway/Buffalo Mountain Discussion

Hi Gerry,

(b) (5) [REDACTED]

[REDACTED]

[REDACTED]

[REDACTED]

... and thanks again for your  
patience!

Warm regards,

Laura Bachle, AICP  
OW - FHWA National Liaison  
U.S. EPA

---

Mailing:  
MC 4502T  
1200 Pennsylvania Ave. NW  
Washington, D.C. 20004  
Direct: (202)566-2468  
FAX: (202)566-1349  
bb# (202)306-7035  
bachle.laura@epa.gov

Courier:  
1301 Constitution Ave. NW  
Room7318F  
Washington, DC 20469

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|<Gerald.Solomon@dot.gov>  
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| To: |  
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| Laura Bachle/DC/USEPA/US@EPA  
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| Cc: |  
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|<Patricia.Cazen@dot.gov>, <Marlys.Osterhues@dot.gov>  
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| 11/12/2010 11:23 AM  
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| RE: King Coal Highway/Buffalo Mountain Discussion  
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Laura  
I apologize for not replying to your email sooner. Your webinar earlier  
this week (which I enjoyed) reminded me that this remained an

outstanding issue.

I agree that a Fed-only discussion would benefit our efforts to address King Coal Highway. I do think it would be important to include our Division office in that discussion (your email reflects that the EPA Region would also participate).

For November dates, I am available on the 22nd, 23rd, 24th, and 29th. I would need to coordinate with Pat and Tom Smith (Division Administrator). If these dates don't work, we can try for early December (possible 3rd, 6th, or 10th).

Please advise if any of these dates work with you. I would also like to schedule our quarterly meeting (with OW and Federal Activities) - possibly coinciding with the meeting on King Coal

Thank you.

Gerry Solomon  
Director  
FHWA Office of Project Development and Environmental Review  
1200 New Jersey Ave SE  
Washington DC 20590  
202 366-2037  
gerald.solomon@dot.gov

-----Original Message-----

From: Bachle.Laura@epamail.epa.gov [mailto:Bachle.Laura@epamail.epa.gov]

Sent: Thursday, October 14, 2010 3:27 PM

To: Solomon, Gerald (FHWA)

Cc: Cazenias, Patricia (FHWA)

Subject: King Coal Highway/Buffalo Mountain Discussion

Hi Gerry,

Pat and I had a brief discussion about moving forward on a briefing for you on this project.

(b) (5)

A large rectangular area of the email is completely redacted with black ink. The redaction covers the majority of the page content below the subject line and above the closing. The text "(b) (5)" is written in red at the top left of this redacted area.

Thanks for your understanding and patience.

Laura Bachle, AICP

OW - FHWA National Liaison  
U.S. EPA

---

Mailing:  
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FAX: (202)566-1349  
bb# (202)306-7035  
bachle.laura@epa.gov

Courier:  
1301 Constitution Ave. NW  
Room7318F  
Washington, DC 20469

## **Buffalo Mountain Surface Mine Mingo County, West Virginia**

- **Issue:** Consol of Kentucky has proposed the construction, operation, and reclamation of an approximately 2313 acre Surface Mine referred to as the Buffalo Mountain Surface Mine. The project involves the construction of 13 valley fills impacting nearly 52,000 linear feet of stream to mine 16,784,000 tons of coal within 10 coal seams. The project's post mine land use would include approximately 5 miles of line and rough grade for the King Coal Highway. This mine proposal is larger than the permitted Spruce No. 1 Surface Mine, which had an EIS conducted during the project review. The Agency has significant new concerns surrounding the KCH due to its relationship with the mine proposal regarding water quality impacts, potential secondary impacts, mitigation, and cumulative impacts that may need to be addressed through the NEPA processes. This project is of great interest to the Governor of West Virginia and directly relates to his agenda to have economically focused post mine land uses.

### **Project History:**

- The Buffalo Mountain Surface Mine project was public noticed on December 3, 2008. No project-specific EIS has been prepared for the Buffalo Mountain Surface Mine.
- EPA provided comments in response to the public notice on January 21, 2009. In that letter EPA raised issues of water quality, alternatives analysis, cumulative impacts and mitigation. In addition, we considered the project to rise to a level of magnitude and the known effects uncertain that it should be evaluated through an EIS.
- The post mining land use is for approximately 5 miles of line and rough grade for the King Coal Highway (KCH). The KCH is a 95 mile alignment for the I-73/74 corridor sponsored by the West Virginia Department of Transportation (WVDOT) in conjunction with the FHWA-WV Division.
- A preliminary Draft Environmental Impact Statement (EIS) for the King Coal Highway was prepared in 1996 and after public and agency involvement, the Draft EIS was signed in 2000; the Final EIS was signed by WVDOT and FHWA-WV Division in June 2000. The King Coal Highway EIS did not discuss the possibility that alignments would be adjusted to accommodate post-mining land use for mining operations within the right-of-way.
- EPA stated in its letters (2000) on the Draft and Final King Coal Highway EISs that due to the length of the corridor and uncertainty of the exact alignment, specific environmental impacts had not been evaluated including for wetlands, streams, communities and secondary and cumulative effects. EPA suggested in its letters that additional NEPA documentation should be prepared if significant issues arise during the design process
- The King Coal Highway EIS studied a 1000-foot wide transportation corridor rather than specific alignments within the corridor. Recent proposed alignments would take advantage of proposed post-mining land use from surface coal mine operations through a public/private partnership (PPP) program developed by the FHWA.
- The PPP is comprised of the WVDOT, FHWA, Mingo County Redevelopment Association, Consol of KY and Cotiga Development and represents that it will save tax payers \$110+ million by leveraging post-mining land use to create line and rough grade for the King Coal Highway.
- The FHWA administration has undertaken a re-evaluation of the King Coal Highway FEIS/ROD for this segment of the highway that would be part of the post-mining land use for the Buffalo Mountain Surface Mine and the coal company's Environmental Information Document will evaluate impacts apart from impacts related to the King Coal Highway alignment.
- The U.S. Army Corps of Engineers may attempt to adopt the King Coal Highway EIS and re-evaluation to satisfy its NEPA obligations for its issuance of Section 404 permits for the mine proposals.



## **Project Background:**

- The proposed project is located in Mingo County, WV with impacts proposed in the Pigeon Creek and Miller Creek sub-watersheds and in the Tug Fork Sub-Basin.
- The project, as proposed, consists of 13 valley fills and will impact nearly 52,000 linear feet (lf) (nearly 10 miles) of tributaries to Pigeon Creek and Miller Creek
- The project is located in the Tug Fork Sub-basin. Four other proposals within the Tug Fork Sub-basin appear on the ECP list. In total this represents approximately 18 miles of proposed stream impacts.
- Tug Fork is listed as a High Quality Stream by WVDNR for fisheries and has TMDLs.
- Pigeon Creek is listed as impaired on the 303(d) list for mining related pollutants; tributary delivers the highest load of Aluminum, Iron, and Manganese than any other tributary to the Tug Fork in West Virginia.
- MIRA average pre-mining conductivity data is 259 uS/cm. Nearby- mined areas (in headwaters of Pigeon Creek) recently sampled by EPA indicate average conductivity of 1175 uS/cm.
- The proposed mitigation include on-site and off-site establishment, on-site and off-site enhancement, off-site preservation and watershed water quality improvements.

## **Concerns:**

NEPA: Significant new circumstances or information relevant to environmental concerns on segments of the King Coal Highway project (water quality impacts, secondary impacts, mitigation, environmental conditions and land use, portions of proposed alignments extending beyond the corridor identified in the EIS) appear to be present and may trigger need for a supplemental EIS (see CEQ 40 FAQ #32; Sec 1502.9 (c)) or new EIS for specific segments. Reexamination of a document greater than five years is recommended in CEQ guidance (40 FAQ, #32). The current King Coal Highway FEIS evaluation of a 1000' corridor is comparable to a Tier I project where preparation of EIS or EAs follows segmentation of the project to assure thorough environmental resource identification, alternatives evaluation, and public involvement (see Sec 1508.28). The Buffalo Mountain Surface Mine appears to have a magnitude of impacts that would warrant an EIS for that project. A Buffalo Mountain EIS could "tier" from the more general King Coal Highway EIS once that document is updated, or could be prepared simultaneously with an updated King Coal Highway EIS or SEIS..

Avoidance and Minimization: EPA believes that further avoidance and minimization measure must be considered. An appropriate evaluation must be conducted to ensure that the combined project is indeed the least environmentally practicable alternative.

Water Quality: Based on the best available science the project as proposed is likely not protective of water quality and is therefore inconsistent with the Section 404(b)(1) Guidelines prohibiting water quality excursions and significant degradation. No new information has been provided to the Agency to address water quality concerns.

Cumulative Impacts (CI): The project is located in the Tug Fork Sub-basin which has extensive mining impacts and has at least 4 other reasonably foreseeable proposals within the sub-basin on the ECP list. The project is will also have impacts to 3 different sub-watersheds (HUC-12). Outlet Pigeon Creek is currently 14%; could increase to 21% if all pending permits are constructed. Headwaters of Pigeon Creek currently 20%; could increase to 24% if all pending permits are constructed. Miller Creek currently 9%; could increase to 16% if all pending permits are constructed. Aerials appear to show relatively un-impacted forested areas.

Mitigation: Mitigation success criteria must be specified. Goal is to ensure that the compensation is ensuring functional replacement.

Environmental Justice: EPA will work with the Corps to ensure that consideration is made to potential adverse impacts on human use characteristics including municipal and private water supplies, recreational and commercial fisheries, water related recreation, or local, state, or national parks.

## Options for Addressing Concerns:

EPA should consider options available to address NEPA concerns which will enable a thorough evaluation and identify means of addressing those issues identified in the Section 404 process.

- A new EIS for the King Coal Highway corridor (from FHWA/WVDOT),  
Pros: holistic, perceived as unbiased, can consider new conditions; address dual P&N, logical termini of segments, mitigation, secondary and cumulative impacts, public involvement, EJ, thorough assessment of fill integrity and leaching potential, may avoid law suits, etc.  
Cons: a long process (likely three years), costly, not likely to be well-received by FHWA, political officials or public
- A supplemental EIS for the King Coal Highway corridor (from FHWA/WVDOT),  
Pros: as above (though would not have new P&N)  
Cons: as above (would not address new P&N, may be insufficient for NEPA if P&N not current)
- New EISs or EAs for segments of the King Coal Highway project (from FHWA/WVDOT/PPP),  
Pros: customary for tiered projects, can adjust documentation to segment-specific situation, could do secondary and cumulative effects, comparative impacts of alternative alignments, etc.  
Cons: complication that existing EIS not done as Tiered EIS; a new EIS/EA may diverge from existing document on P&N, etc; concern on how segments would be determined/coordinated (logical termini; decision on alignment for one segment effects other projects); data collection may be limited and rushed, thorough cumulative effects may be difficult to develop
- Re-evaluation of the King Coal Highway EIS and adoption of methods to strengthen environmental protection and mitigation (which could include the decision to proceed to new NEPA documentation if warranted or not if the ROD is determined to be satisfactory) (from FHWA/WVDOT)  
Pros: customize assessment to each segment, flexible level of data required; emphasize resource protection and mitigation, most likely to have buy-in from FHWA; would be useful as screen, with NEPA assessment follow as needed  
Cons: may be insufficient for NEPA based on current conditions, no public involvement likely, likely to be less thorough in consideration of alternatives, secondary and cumulative effects, etc.
- Site by site Section 404 evaluation, including potentially project-specific EISs, of areas where highway will constitute part of post-mining land use (from EPA, Corps; applicant)  
Pros: agency could control data collection and assessment requirements  
Cons: may be insufficient for NEPA (problem of dual P&N, requires separate analyses of project needs, range of alternatives to address each need, issue of segmentation, etc), potential disagreement between agencies on conclusions from data, little public involvement/transparency

## Interested Stakeholders:

Consol of Kentucky – Company proposing the surface mine and part of the PPP.

Cotiga Development– Landowners of the project area and part of the PPP.

State of West Virginia– Governor Manchin has significant interest in this project and the potential public savings associated with it. He has personally attended meetings with EPA discussing this project. County Commissioners see this as a vital part of the county's development. The WVDOH has interest as part of the PPP and the potential savings associated with the construction of the highway.

Corps Huntington District – Agency to issue the CWA Section 404 permit.

FHWA- Part of the PPP. Overseeing the reevaluation of the FEIS/ROD.



Consol of Kentucky, Buffalo Mtn Surface Mine, PN 2008-491

Located in Mingo County, WV; Pigeon & Miller Creeks Subwatersheds; Tug Watershed

Updated 02/05/2010 MP

### **Impacts**

- Proposal for the construction, operation, and reclamation of the ~ 2313 acre Buffalo Mountain Surface Mine. 16,784,000 tons of coal and 10 coal seams.
- Proposal for impacts to 52,014 lf: Permanent 43,114 (P 12,252; I 23,354; E 7,508); Temporary 8900 (P 7,333; I 1,530; E 40)
- 13 Valley Fills, 4 EPZs, several mine-through areas, 17 temp drainage control structures, & 6 temp stream crossings.
- PMLU – apprx. 5 miles of line and rough grade for KCH. Utilizing ~ 8 VF
- This section of Hwy was presented by the WVDOH/FHWA during a public meeting in Dec. 08.
- Evidence of water quality impacts likely and will increase impairment of water quality to downstream receiving waters
- Utilizing combination of Area/MTM/Steep Slope/Contour with limited Auger/Highwall.
- No information regarding minimization techniques in the PN

### **Watershed Context**

- Portions of the Buffalo Mtn Surface Mine drain to 3 different HUC 12's; Outlet Pigeon Creek (primary); Miller Creek (1 VF) and the Headwaters of Pigeon Creek (1 VF)
- Pigeon Creek is listed as impaired on the 303(d) list for mining related pollutants; tributary delivers the highest load of Aluminum, Iron, and Manganese than any other tributary to the Tug Fork in West Virginia.
- Tug Fork is listed as a High Quality Stream by WVDNR for fisheries. Has TMDL.
- Outlet Pigeon Creek is currently 14%; could increase to 21% if all pending permits are constructed.
- Headwaters of Pigeon Creek currently 20%; could increase to 24% if all pending permits are constructed
- Miller Creek currently 9%; could increase to 16% if all pending permits are constructed.
- Aerials appear to show relatively un-impacted forested areas.

### **Water Chemistry**

- MIRA average premining conductivity data is 259 uS/cm. Nearby mined areas (in headwaters of Pigeon Creek) recently sampled by EPA indicate average conductivity of 1175 uS/cm.
- WVDEP sampled Miller Creek on 06/17/1998. The WVSCI score was 67.9 indicating some degradation, but barely under the impairment threshold of 68. pH: 7.4 su, Sp Cond : 157uS/cm, RBP Habitat was suboptimal. This sampling date appears to predate any mining (Google).
- WVDEP sampled Pigeonroost Creek on 06/16/1998. The WVSCI was 83.4, indicating very good, comparable to reference quality conditions. pH: 7.2 su, Sp Cond: 57 , RBP habitat was suboptimal. This sampling date predates any mining (Google).
- WVDEP also sampled Pigeon Creek mainstem, between Trace Fork and Conley Branch in 1998. At that time, Pigeon Creek was already impaired with a WVSCI score of 52 and Sp. Cond of 523 uS/cm. RBP habitat was marginal.
- As noted above, Pigeon Creek is listed as impaired on the 303(d) list for mining related pollutants and has a TMDL developed for total aluminum, iron, manganese and pH.
- Other adjacent data: WVDEP also sampled Rockhouse Fork (nearby trib to Pigeon Creek to the east) in 2003. The WVSCI was only 47.9 and the GLIMPSS was 25. pH: 7.9 Sp Cond (umhos/cm): 717, RBP habitat suboptimal. At that time, this tributary

drained mined areas including White Flame Energy's Surface Mine #9. Since that time, more mining has occurred (e.g WhiteFlame Energy's Surface Mine #10 (Google)).

•  
**Mitigation**

- Proposed within the Tug Fork watershed using on-site and off-site and in and out of kind mitigation.
- Combination of headwater re-establishment, establishment and preservation, restoration and enhancement of degraded channels downstream.
- Restoration of temporary impacts.
- Water Quality treatment off-site
- In line w/ the Pigeon Creek Watershed Restoration Plan

**What are we asking for?**

- Condition 404 permit to consider water quality; can not cause to contribute to a violation of water quality standards. Ask for a RPA characterizing the effluent including sp. Conductance, TDS, and appropriate ion/cations. Analysis should consider pre-mining instream conditions including biological. Should develop BMPs to minimize export of degraded water, and a monitoring plan for all phases of operation.
- Watershed Based Mitigation plan. Plan should account for all existing functions of the proposed impacted streams including detrital transport, flow, providing good water quality downstream, native biota. No credit given for created channels in sediment and groin ditches that export degraded water downstream. Performance measures that provide for chemical, physical, and biological. Ensuring all functions are being replaced and we are achieving similar water chemistry and biological communities.
- Provide a thorough alternatives analysis examining both project purposes to ensure the least environmentally damaging practicable alternative is identified for both the Hwy and the Surface Mine. Include an economic analysis.
- Examine and exhaust all available means to avoid and minimize impacts to aquatic resources to leave a maximized aquatic resource in as much as possible state of natural condition including minimizing resource extraction.
- Cumulative Impact analysis at HUC 12 level, considering all past, present and reasonably foreseeable impacts, including development, commercial, industrial, and residential; timbering; oil and gas exploration; etc. Any perturbations that would have an affect on the aquatic communities.
- Consider mitigation option to address the cumulative impacts in addition to site specific impacts.

Matthew  
Klasen/DC/USEPA/US  
12/10/2010 04:46 PM

To Karyn Wendelowski  
cc Gregory Peck  
bcc  
Subject Fw: DOI Comments on EPA Docket ID No.  
EPA-HQ-OW-2010-0315

Hey Karyn,

FYI below for DOI comments on the guidance.

In particular, there's this statement:

We also are concerned that EPA's guidance, which has such significant effects on permitting surface coal mining operations, took effect immediately upon publication without an opportunity for public notice and comment. As the memorandum has general and prospective applicability to the public, its requirements read more like a rule than guidance. As such, we believe the document should have been issued through a process similar to the requirements of the Administrative Procedure Act, thus affording the public an appropriate review and comment opportunity.

Ciao,  
Matt

---

Matt Klasen  
U.S. Environmental Protection Agency  
Office of Water (IO)  
202-566-0780  
cell (202) 380-7229

----- Forwarded by Matthew Klasen/DC/USEPA/US on 12/10/2010 04:45 PM -----

From: Gregory Peck/DC/USEPA/US  
To: Matthew Klasen/DC/USEPA/US@EPA  
Date: 12/10/2010 01:22 PM  
Subject: Fw: DOI Comments on EPA Docket ID No. EPA-HQ-OW-2010-0315

---

----- Forwarded by Gregory Peck/DC/USEPA/US on 12/10/2010 01:22 PM -----

From: "Sutton, Loretta B" <Loretta\_Sutton@ios.doi.gov>  
To: OW-Docket@EPA  
Cc: Gregory Peck/DC/USEPA/US@EPA, David Evans/DC/USEPA/US@EPA, Timothy Landers/DC/USEPA/US@EPA, "Ziewitz, Jerry" <jerry\_ziewitz@fws.gov>, "Blanchard, Mary Josie" <MaryJosie\_Blanchard@ios.doi.gov>, "Taylor, Willie R" <Willie\_Taylor@ios.doi.gov>  
Date: 12/10/2010 01:11 PM  
Subject: FW: DOI Comments on EPA Docket ID No. EPA-HQ-OW-2010-0315

---

EPA Water Docket (ID No. EPA-HQ-OW-2010-0315),

This email transmits the U.S. Department of the Interior's (DOI) comments on the EPA's Guidance Memorandum "Improving EPA Review of Appalachian Surface Coal Mining Operations Under the CWA, NEPA, and E.O. 12898".

Thank you for the opportunity to provide comments.

Loretta B. Sutton  
Program Analyst  
U.S. Department of the Interior (MS-2462); Room: 2444  
Office of Environmental Policy and Compliance (PEP)  
Voice: 202-208-7565; Fax: 202-208-6970  
Loretta\_Sutton@ios.doi.gov



DOI Comments on EPA Guidance Appalachian Surface Coal Mining Ops.pdf



# United States Department of the Interior

OFFICE OF THE SECRETARY  
Washington, D.C. 20240

DEC 10 2010

ER 10/339

U.S. Environmental Protection Agency  
Water Docket (EPA-HQ-OW-2010-0315)  
Mail Code: 2822T  
1200 Pennsylvania Avenue NW  
Washington, DC 20460

Dear Sir or Madam:

The U.S. Department of the Interior (Department) has reviewed the U.S. Environmental Protection Agency's (EPA) Guidance Memorandum "Improving EPA Review of Appalachian Surface Coal Mining Operations under the Clean Water Act (CWA), National Environmental Policy Act (NEPA), and the Environmental Justice Executive Order (E.O. 12898)". We offer the following comments based upon the analysis of our U.S. Fish and Wildlife Service (USFWS), and U.S. Office of Surface Mining, Reclamation and Enforcement (OSM).

We find that the draft memorandum meets its stated purpose by clarifying EPA's role and expectations in coordinating with Federal and state partners to assure that Appalachian surface coal mining operations comply with the CWA, NEPA, and E.O. 12898 more consistently, effectively, and timely. We also believe that the guidance is consistent with the June 11, 2009, Memorandum of Understanding between the U.S. Department of the Army, the Department and the EPA, under which the agencies seek to reduce the harmful environmental consequences of Appalachian surface coal mining operations, and with the Department's efforts, to reduce the adverse impacts of surface mining.

We support the EPA's commitment to ensuring that appropriate water quality based effluent limits (WQBELs) are included in state-issued National Pollutant Discharge Elimination System permits in order to meet the relevant narrative and numeric water quality standards and comply with the requirements of the CWA. We also support EPA's commitment to ensure that, consistent with Section 404 of the CWA, water quality and environmental integrity must be protected, surface coal mining operations must avoid and minimize environmental impacts, effects from surface coal mining operations must be effectively mitigated, and water quality and biological parameters must be monitored.



We recommend that the EPA work closely with its Regional Offices to develop a clear and consistent set of applicable guidelines. We also recommend that the EPA's Regional Offices relay this information to the local Corps of Engineers field offices, state governments, and the industry to assist applicants in submitting complete project proposals and to give regulatory agencies the ability to conduct thorough permit reviews within a reasonable timeframe.

While we applaud EPA's effort and intent, we are concerned that enforcing the conductivity thresholds in the guidance can have unintended consequences. Regarding the emerging science of conductivity impacts on stream biology, we agree with EPA that protection of water is paramount and is the primary goal of the CWA. However, we believe that additional information is needed to ascertain the impacts on stream health both temporally and geographically. While the Pond study cited by EPA focused on water emanating from valley fills, we believe that waters infiltrating the fresh spoil of any surface mining operation will exhibit high levels of total dissolved solids (TDS). In addition, underground mines and coal preparation waste facilities historically have exhibited high and more persistent levels of TDS than surface mines.<sup>1</sup> Other studies have shown that TDS as a whole might not be the best indicator of potential toxicity, and that certain species are more intolerant to specific major ions.<sup>2</sup>

We also are concerned that EPA's guidance, which has such significant effects on permitting surface coal mining operations, took effect immediately upon publication without an opportunity for public notice and comment. As the memorandum has general and prospective applicability to the public, its requirements read more like a rule than guidance. As such, we believe the document should have been issued through a process similar to the requirements of the Administrative Procedure Act, thus affording the public an appropriate review and comment opportunity.

Lastly, we note that the organizational hierarchy in the guidance includes an entire section between IV.C and IV.D that does not have a lettered heading to set it apart from C and D. Instead, under section IV.C, the document includes numbers 1-7 on pages 20-24 followed immediately by numbers 1-6 on pages 24-27. Section D begins on page 27. It appears as though numbers 1-6 should be in section D, while existing D should become E.

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<sup>1</sup> Demchak, J., Skousen, and McDonald, L.M. 2004. Longevity of Acid Discharges from Underground Mines Located Above the Regional Water Table. *J. Environmental Quality*, 33:656-668.

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We appreciate the opportunity to provide input on the proposed Guidance Memorandum. If you have any questions regarding these comments, please contact Carrie Lona, USFWS, at (502) 695-0468, Ext. 103, [carrie\\_lona@fws.gov](mailto:carrie_lona@fws.gov); Sterling Rideout, OSM, at (202) 208-4264, [srideout@osmre.gov](mailto:srideout@osmre.gov); or Loretta Sutton of my staff at (202) 208-7565, [Loretta\\_Sutton@ios.doi.gov](mailto:Loretta_Sutton@ios.doi.gov).

Sincerely,

A handwritten signature in black ink, appearing to read "Willie R. Taylor", with a large, stylized flourish extending to the right.

Willie R. Taylor, Director  
Office of Environmental Policy  
and Compliance

Matthew  
Klasen/DC/USEPA/US  
12/10/2010 04:50 PM

To lleuck  
cc  
bcc  
Subject Fw: DOI Comments on EPA Docket ID No.  
EPA-HQ-OW-2010-0315

Hey Lauren,

(b) (5)

Enjoy the weekend,  
Matt

-----  
Matt Klasen  
U.S. Environmental Protection Agency  
Office of Water (IO)  
202-566-0780  
cell (202) 380-7229

----- Forwarded by Matthew Klasen/DC/USEPA/US on 12/10/2010 04:46 PM -----

From: Gregory Peck/DC/USEPA/US  
To: Matthew Klasen/DC/USEPA/US@EPA  
Date: 12/10/2010 01:22 PM  
Subject: Fw: DOI Comments on EPA Docket ID No. EPA-HQ-OW-2010-0315

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From: "Sutton, Loretta B" <Loretta\_Sutton@ios.doi.gov>  
To: OW-Docket@EPA  
Cc: Gregory Peck/DC/USEPA/US@EPA, David Evans/DC/USEPA/US@EPA, Timothy Landers/DC/USEPA/US@EPA, "Ziewitz, Jerry" <jerry\_ziewitz@fws.gov>, "Blanchard, Mary Josie" <MaryJosie\_Blanchard@ios.doi.gov>, "Taylor, Willie R" <Willie\_Taylor@ios.doi.gov>  
Date: 12/10/2010 01:11 PM  
Subject: FW: DOI Comments on EPA Docket ID No. EPA-HQ-OW-2010-0315

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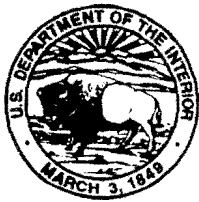
Thank you for the opportunity to provide comments.

Loretta B. Sutton

Program Analyst  
U.S. Department of the Interior (MS-2462); Room: 2444  
Office of Environmental Policy and Compliance (PEP)  
Voice: 202-208-7565; Fax: 202-208-6970  
Loretta\_Sutton@ios.doi.gov



DOI Comments on EPA Guidance Appalachian Surface Coal Mining Ops.pdf



# United States Department of the Interior

OFFICE OF THE SECRETARY  
Washington, D.C. 20240

DEC 10 2010

ER 10/339

U.S. Environmental Protection Agency  
Water Docket (EPA-HQ-OW-2010-0315)  
Mail Code: 2822T  
1200 Pennsylvania Avenue NW  
Washington, DC 20460

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Sincerely,

A handwritten signature in black ink, appearing to read "Willie R. Taylor", with a large, stylized flourish extending to the right.

Willie R. Taylor, Director  
Office of Environmental Policy  
and Compliance

Matthew  
Klasen/DC/USEPA/US  
12/14/2010 03:38 PM

To Karyn Wendelowski  
cc "Morris, Cynthia (ENRD)", "Amaditz, Kenneth (ENRD)", Kevin  
Minoli  
bcc  
Subject (b) (5)

(b) (5)

(b) (5)

(b) (5)

(b) (5)

(b) (5)

(b) (5)

(b) (5)

(b) (5)

(b) (5)

Karyn Wendelowski (b) (5)

12/14/2010 03:07:43 PM

From: Karyn Wendelowski/DC/USEPA/US  
To: "Amaditz, Kenneth (ENRD)" <KAmaditz@ENRD.USDOJ.GOV>  
Cc: "Morris, Cynthia (ENRD)" <CMorris@ENRD.USDOJ.GOV>, Kevin Minoli/DC/USEPA/US@EPA,  
Matthew Klasen/DC/USEPA/US@EPA  
Date: 12/14/2010 03:07 PM  
Subject: (b) (5)

(b)(5) ACP/AWP



(b)(5) ACP/AWP [Redacted]

[Redacted] [Redacted] [Redacted] [Redacted]

Jeffrey Lapp/R3/USEPA/US

12/21/2010 12:29 PM

To Brian Topping, Christopher Hunter

cc

bcc

Subject Fw: CCIR for Spring Branch (UNCLASSIFIED)

----- Forwarded by Jeffrey Lapp/R3/USEPA/US on 12/21/2010 12:29 PM -----

From: "Mullins, Ginger LRH" (b) (6)  
To: Jeffrey Lapp/R3/USEPA/US@EPA  
Cc: Jessica Martinsen/R3/USEPA/US@EPA, "Taylor, Mark A LRH" (b) (6)  
Date: 12/17/2010 12:43 PM  
Subject: Fw: CCIR for Spring Branch (UNCLASSIFIED)

---

Jeff,

This email is written to respectfully request the 60 day clock to begin for the proposed Spring Branch Deep Mine in Mingo County, WV. Details are below. Thank you very much. I hope you and Jess have a wonderful Christmas and a Happy New Year!

Sincerely,  
Ginger

----- Original Message -----

From: Taylor, Mark A LRH  
To: Mullins, Ginger LRH  
Sent: Fri Dec 17 09:28:20 2010  
Subject: CCIR for Spring Branch (UNCLASSIFIED)

Classification: UNCLASSIFIED  
Caveats: FOUO

Ginger,

Here is the CCIR for Spring Branch, I also pasted in email. Short of it: temp (5yrs) deep mine face up and operational area; 871 lf or impact; mitigation reconstruction of stream and ILF for temporal loss.

Do you want a bigger Executive Summary for USEPA notification?

Thanks

Mark

Type: Mining NWP 50  
District: LRH  
State: WV  
Action: ECP 60 day notification to USEPA

- a. Applicant name: Consol of Kentucky
- b. ORM application number: LRH-2009-428-TUG
- c. Mine name and location: Spring Branch No. 3 Deep Mine
  - i. County: Mingo

(TUG) ii. Watershed: Left Fork of Riffe Branch

iii. Congressional District: Rahall

d. Proposed impacts to waters of the U.S.: The applicant proposes to construct a deep mine face up and operational area temporarily (5 years) impacting 871 linear feet of stream.

e. Key issues, if any: ECP meeting held 2/16/10, USEPA expressed no concerns. SMCRA was pending until recently (reason for delay in permit decision).

f. Date permit decision will be made: Starting the 60 day clock on 12/17/10.

g. Talking points for chain of command

i. General regional talking points: deep mine area, not a lot concern other than it is on ECP list.

ii. Project specific talking points:

- Impacts: 871 linear feet of stream.
- Compensatory Mitigation: On-site reconstruction of 871 linear feet of stream and \$104,520 payment to the WVILF Program for temporal loss.

h. List of District POCs

i. Regulatory Specialist: Samantha Dailey

ii. Responsible Regulatory Chief: Ginger

Mullins

iii. Signatory Level: Section Chief

(Mark Taylor)

iv. Public Affairs POC : Peggy Noel

Classification: UNCLASSIFIED

Caveats: FOUO



CCIR Spring Branch #3 Deep Mine.doc

**Type: Mining NWP 50**

**District: LRH**

**State: WV**

**Action: ECP 60 day notification to USEPA**

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**b. ORM application number:** LRH-2009-428-TUG

**c. Mine name and location:** Spring Branch No. 3 Deep Mine

**i. County:** Mingo

**ii. Watershed:** Left Fork of Riffe Branch (TUG)

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**i. Regulatory Specialist:** Samantha Dailey

**ii. Responsible Regulatory Chief:** Ginger Mullins

**iii. Signatory Level:** Section Chief (Mark Taylor)

**iv. Public Affairs POC :** Peggy Noel